Science and Technology for Chem-Bio Information Systems (S&T CBIS)
"Translating Lessons Learned into Systems Requirements"

25 -28 October 2005

Agenda

Tuesday, 26 October 2005 - General Session

Keynotes:

- Systems Perspective on Information Systems, BG Stephen V. Reeves, USA, Joint Program Executive Officer for Chemical Biological Defense
- Chemical and Biological Technology for the Joint Warfighter, COL Benjamin Hagar, Joint Science & Technology Office, CBDP, and Chemical and Biological Technologies Directorate, Defense Threat Reduction Agency
- Joint Requirements Office for Chemical, Biological, Radiological, and Nuclear Defense (JRO for CBRND), LTC Mark Bohannon, VC, USA

Technology Transition Overview - How do I get the Cheese?, Mr. Curt Wilhide, Chief, Advanced Technology and Transition

Joint Project Manager Information Systems Program Overview, CAPT Tom O'Keefe, USN, JPM Information Systems, Joint Program Executive Office for Chemical and Biological Defense

Joint Effects Model Program Overview, Mr. Tom Smith, JEM Acquisition Program Manager

Joint Operational Effects Federation Program Overview, Dr. Jerry Hoffman, JOEF Acquisition Program Manager

Joint Warning and Reporting Network Program Overview, Mr. Chuck Walker, JWARN Acquisition Program Manager, Joint Project Manager Information Systems

Joint Project Manager Information Systems Integration Overview, Mr. Kevin Adams, JPM IS Lead Integrator, SSA Director

Joint Science and Technology Office Program Overview, Mr. Chuck Fromer, Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD)

Environmental Hazard Prediction Thrust Area Overview, Mr. John Pace, Joint Science and Technology Office, Defense Threat Reduction Agency

Operations Effects Thrust Area Overview, Mr. Mark Fagan, OETA Manager

Battlespace Management Thrust Area Overview, Mr. William J. Ginley, Battlespace Management Thrust Area Manager, Edgewood Chemical Biological Center

Wednesday, 27 October 2005 - General Session

Agent Fate Program Overview, Dr. James Savage, Research Development and Engineering Command, ECBC

CBDP Decision Support Tools and Methodologies, Mr. Scott Cahoon, Defense Threat Reduction Agency

BREAKOUT SESSION A
***Working Group I** - Dispersion Modeling and Sensor Data Fusion:*
Session A-I Agenda

- Overview of Hazard Prediction Modeling Program, Mr. John Pace, Joint Science and Technology Office, Defense Threat Reduction Agency
- RCB Weapon Environment Prediction: Source Term Estimation, Mr. Paul Thomas, Mr. Peter Robins, and Ronni Rapley
- High Level Architecture Compliance: Source Term Estimation Demo, Mr. Ian Griffiths, Mr. Andrew Solman, and Mr. Ben Swindlehurst
- STEM II Bio Data *(Video)*
- Mobil Array *(Video)*

***Working Group II** - Chemical Agent Persistence and Prediction Modeling:*

Session A-II Agenda

- Droplet Reaction and Evaporation of Agents Model (DREAM), Mr. A.R.T. Hin, TNO, The Netherlands
- Chemical Agent Fate Program (CAFP): Development of an Evaporation Model for HD on Non-Porous Surfaces, Mr. Brad Dooley, California Institute of Technology and H. K. Navaz, Kettering University
  - Sample Animated Droplet Topology - 1 L Droplets *(Video)*
  - Sample Animated Droplet Topology - 6 L Droplets *(Video)*
  - Sample Animated Droplet Topology - 9 L Droplets *(Video)*

- Applying Quantum Chemical Theory to the Fate of Chemical Warfare Agents, Dr. Tom J. Evans and Dr. Tom Stark, Cubic Applications, Inc.

Working Group III - *Battlespace Management**:***

Session A-III Agenda

- CB Defense Battle Management, Mr. William J. Ginley, Battlespace Management Thrust Area Manager, Edgewood Chemical Biological Center
- Next Generation Chem Bio Battle Management System, Mr. Jim Reilly, AFRL/IFSA

Working Group IV - *Decision Making and Support**:***
Session A-IV Agenda

- Analytical Capabilities Development, Dr. Jeffrey Grotte, Institute for Defense Analyses
- Virtual Prototyping Feasibility/Benefit and CB Common Knowledge Base BA05MSB061, Mr. Michael Kierzewski, ECB, and Mr. Scott Kothenbeutel, Battelle
- DTRA -Modeling and Simulation/Battlespace - BO05MSB070: Multivariate Decision Support Tool for CB Defense, Dr. Frank Gilfeather, UNM

Working Group V - *Special Topics**:** Test and Evaluation**:***
Session A-V Agenda

- Warning, the Critical Element to Mitigate the Effects of a CBRN Attack, Dr. Alan Avidan MadahCom, Inc.
- Sensor Placement Optimization, Mr. Keith Gardner, Northrop Grumman IT

BREAKOUT SESSION B
Working Group I - *Dispersion Modeling and Sensor Data Fusion**:***
Session B-I Agenda

- Fusion of Sensor and Model Data, Dr. Deborah Fish, Mr. Oliver Lanning and Mr. Paul Thomas
- Chemical/Biological Source Characterization, Richard Fry, DTRA, R. Ian Sykes, L-3 Titan, Ronald Kolbe, NGIT
- Sensor Placement Optimization, Mr. Keith Gardner, Northrop Grumman IT
- Sensor Location & Optimization Tool Set: Presentation - Paper, Mr. Michael J. Smith, ITT Industries, Advanced Engineering & Sciences
- Hazard Prediction with Nowcasting, Jason Nachamkin and John Cook, Naval Research Laboratory, and Michael Frost, Daniel Martinez, and Gary Sprung Computer Sciences Corporation
- Tracking Atmospheric Plumes Using Stand-off Sensor Data, Robert C. Brown, David Dussault, and Richard C. Miake-Lye Aerodyne Research, Inc. Patrick Heimbach, Department of Oceanography, Massachusetts Institute of Technology

Working Group II - *Special Topics I**:***
Session B-II Agenda

- Chemical, Biological, Radiological, and Nuclear (CBRN) and Medical Communities of Interest (COI) Information Sharing, Mr. Doug Hardy, JPM IS SSA Manager
- Providing Capabilities-Based Analytic Support In Dynamic Operational Environments, Mr. Mark Neff, Mr. Greg Wells and Mr. E. Mark Chicoine, Booze / Allen / Hamilton
- Development and Implementation of a Model for Predicting the Aerosolization of Agents in a Stack, Teri J. Robertson, Douglas S. Burns, Jeffrey J. Piotrowski, Dustin B. Phelps, Veeradej Chynwat and Eileen P. Corelli, ENSCO, Inc.
- Contamination Avoidance at Seaports of Debarkation: Presentation - Paper, Mr. Donald W. Macfarlane, David H. Drummond and William J. Ginley, NBC Battlefield Management Team, Edgewood Chemical Biological Center
- Advances in Biotechnology and the Biosciences for Warfighter Performance and Protection, Dr. Larry Regens, University of Oklahoma Health Sciences Center

Working Group III - *Battlespace Management**:***
Session B-III Agenda

- A Bayesian Approach for Assessing Confidence in a Biological Warfare (BW) Detection Event, Mr. Patrick L. Berry, U.S. Army Edgewood CB Center
- A New Bio IMS for Simultaneous Detection of CWAs and Biomaterials , Dr. Jürgen Leonhardt Flight Services, Inc
- Chem-Bio Protection Without Chem-Bio Sensors: Low Cost, Dual Use, Alternative Sensor and Information Architectures, Mr. Steven S. Streetman, ENSCO, Inc.

Working Group IV - *Decision Making and Support**:***
Session B-IV Agenda

- The Chemical and Biological Defense Information Analysis Center (CBIAC), a Knowledge Management Source for Authoritative Information, Donald McGonigle, KM Program Manager
- Flatland Visualization of A Decision Support Tool Architecture, Mr. Thomas Preston Caudell, Department of ECE, University of New Mexico
- Scenarios with the CBRN Data Model, Stephen Helmreich, Computing Research Laboratory, NMSU and Sundara Vadlamudi and Markus Binder, Monterey

Institute of International Studies

- Machine Intelligence in Decision-making (MInD) Automated Generation of CB Attack Engagement Scenario Variants, Nadipuram R. Prasad, Arjun S. Rangamani, Timothy J. Ross, M. M. Reda Taha, Frank Gilfeather
- Methods for Understanding Human Interface Requirements for Decision Support Tools, Bill Ogden, Jim Cowie, and Chris Fields, New Mexico State University
- Allocation of Resources in CB Defense: Optimization and Ranking, J. Cowie, H. Dang, B. Li, Hung T. Nguyen, NMSU and F. Gilfeather, UNM

Working Group V** - Special Topics**: Test and Evaluation:
Session B-V Agenda

- Test and Evaluation (T&E) Thrust Area Overview, Eric Lowenstein, T&E Manager, Modeling & Simulation / Battlespace
- Reliable Discrimination of High Explosive and Chemical / Biological Artillery Using Acoustic Sensors, Myron E. Hohil, Sachi Desai, and Amir Morcos, US Army RDECOM-ARDEC
- Infrared Scene Simulation for Chemical Standoff Detection System Evaluation, Peter Mantica, Chris Lietzke, and Jer Zimmermann, ITT Industries, Advanced Engineering and Sciences Division and Fran D'Amico, Edgewood Chemical Biological Center ARDEC
- Neutrotest - A Neutron Based Nondestructive Device for Explosive Detection, Dr. Jürgen Leonhardt
- Dynamic Multi Sensor Management System, Mr. Thomas Sanderson and Mr. Fred Yacoby
- A Bayesian Approach for Assessing Confidence in a Biological Warfare (BW) Detection Event, Mr. Patrick L. Berry, U.S. Army Edgewood CB Center

Thursday, 28 October 2005

BREAKOUT SESSION C
Working Group I** - Dispersion Modeling and Sensor Data Fusion**:
Session C-I Agenda

- An Atmospheric Chemistry Module for Modeling Toxic Industrial Chemicals (TICs) in SCIPUFF, Douglas S Burns, Veeradej Chynwat, Jeffrey J Piotrowski, Kia Tavares, and Floyd Wiseman, ENSCO, Inc.
- Chemical and Biological Hazard Environmental Prediction, Mr. Michael Armistead, NSWC, Dahlgren Division (NSWCDD)
- Development and Implementation of a Model for Predicting the Aerosolization of Agents in a Stack, Teri J. Robertson, Douglas S. Burns, Jeffrey J. Piotrowski, Dustin B. Phelps, Veeradej Chynwat and Eileen P. Corelli, ENSCO, Inc.
- Nowcasting and Urban Interactive Modeling Using Robotic and Remotely Sensed Data, James Cogan, Robert Dumais, and Yansen Wang, Meteorological Modeling Branch, Battlefield Environment Division, Computational & Information Sciences Directorate, U.S. Army Research Laboratory

- MSG Ground *(Video)*
- Quasi Steady Run *(Video)*
- Meandering Wind *(Video)*
- Measurement of Coastal & Littoral Toxic Material Tracer Dispersion, Dr. Robert E. Marshall
- Coupled Air -- Sea Modeling for Improved Coastal Dispersion Prediction, Julie Pullen, Marine Meteorology Division, Naval Research Laboratory

Working Group II** - Current Ops Effect S & T Projects**:
Session C-II Agenda

- JOEF Prototype Development Activities, Dr. Tom Stark, Cubic Defense Applications
- Next Generation Modeling of Operational Effects and CHEMRAT and Updating Air Force Manuals 10-2602 & 10-2517, Maj William Greer, AFRL HEPC
- Impact Assessment Tool, Dr. Ben Swindlehurst, Dstl, Mr. Darrell Lochtefeld, Anteon Corporation and Mr. Andrew Solman, Dstl
    - AOCA *(Video)*
    - Trace Double *(Video)*

- CB System Military Worth Assessment Toolkit, Chris Gaughan, ECBC, Dennis Jones, ITT, Derrick Briscoe, ITT, and Jim Sunkes, ITT
- Predictive Models for Chem-Bio Human Response, Casualty Human Response, Estimation and Patient Loads, Gene McClellan, Karen Cheng, and Jason Rodriguez

Working Group III** - Battlespace Management**:
Session C-III Agenda

- "Net-Ready" CBRN Sensors – A Way Forward…, Chuck Datte, Ritesh Patel and David W. Godso
- Wirelessly Enabling Legacy Sensor Systems for Rapid Deployment and Monitoring, Mr. Joshua Pressnell, RTI
- Dynamic Multi Sensor Management System, Mr. Thomas Sanderson and Mr. Fred Yacoby

Working Group IV** - Decision Making and Support**:
Session C-IV Agenda

- Monotone Measure Theory as a Method for Combining Evidence in Threat Scenarios, Greg M. Chavez, Timothy J. Ross, Mahmoud Reda Taha, Ram Prasad
- Algorithmically Generated Music Enhances VR Decision Support Tool, Dr. Panaiotis, Department of Music & Department of Electrical and Computer Engineering, The University of New Mexico
- Exploring Optimization Methodologies for Systematic Identification of Optimal Defense Measures for Mitigating CB Attacks, Roshan Rammohan, Molly McCuskey, Mahmoud Reda Taha, Tim Ross and Frank Gilfeather, University of New Mexico and Ram Prasad, New Mexico State University
- DTRA -Modeling and Simulation/Battlespace - BO05MSB070: Multivariate Decision Support Tool for CB Defense, Dr. Frank Gilfeather, UNM

Working Group V** - Special Topics**: Test and Evaluation:
Session C-V Agenda

- CBRN Data Model CBRN Data Model Implementation Approach, Mr. William Snee, MSIAC/ Alion Science and Technology and Professor Tom Johnson, Naval Postgraduate School
- Chemical Homeland Security System: C-HoSS, Mr. Kevin Kennedy, Chemical Compliance Systems, Inc.

BREAKOUT SESSION D
Working Group I** - Dispersion Modeling and Sensor Data Fusion**:
Session D-I Agenda

- Release and Atmospheric Dispersal of Liquid Agents, Theo Theofanous (PI), University of California and Rich Couch, Program Manager, Lawrence Livermore National Laboratory
- Modeling and Simulation to Support Virtual Chemical Hazard Environments, Dr. Jeffery D. Peterson, Dr. James A. Kleimeyer and Dr. Richard J. Green, West Desert Test Center, Dugway Proving Ground
- Proposed Translation of Joint Effects Model (JEM) Accuracy Requirement Into a Measurable Acceptability Criterion, Steve Warner, Nathan Platt and James F. Heagy, Institute for Defense Analyses

Working Group II** - Operations Effects Modeling**:
Session D-II Agenda

- Combined Defense, Mr. Keith Gardner, Northrop Grumman IT
- Health Effects Decision Support Tool for Civilian CB Air and Water Attack Scenarios, Dr. Shanna Collie, Toxicologist and Project Manager, Tetra Tech
- Reality Simulation to Train for Prevention, Deterrence, Response, and Recovery for Chem Bio Events, Mr. Scott Milburn, Reality Response
  - SVS at Fort Benning *(Video)*
  - Dismounted Simulation *(Video)*

Monday, October 24

3:00 PM-5:00 PM	Registration

Tuesday, October 25

7:30AM -8:30AM	Late Registration and Continental Breakfast
8:30AM-8:45AM	Welcome and Introduction
8:45AM-9:15AM	***Keynote* – BG Stephen V. Reeves, USA** Joint Program Executive Officer for Chemical Biological Defense
9:15AM-9:45AM	***Keynote* – Dr. Charles R. Gallaway** Director Chem Bio Defense Science and Technology Directorate Defense Threat Reduction Agency
9:45AM-10:15AM	***Keynote* – COL Don Bailey, USA** Deputy Director, Joint Requirements Office for Chemical Biological, Radiological and Nuclear Defense
10:15AM-10:45AM	**Break**
10:45AM-11:10AM	Technology Transitioning Overview
11:10AM-11:35AM	Joint Project Manager Information Systems Program Overview
11:35AM-1:00PM	**Lunch**
1:00PM-1:30PM	Joint Effects Model Program Overview
1:30PM-2:00PM	Joint Operational Effects Federation Program Overview
2:00PM-2:30PM	Joint Warning and Reporting Network Program Overview
2:30PM-3:00PM	Joint Project Manager Information Systems Integration Overview
3:00PM-3:30PM	**Break** *& Joint Project Manager Information Systems Demonstration*
3:30PM-4:00PM	Joint Science and Technology Office Program Overview
4:00PM-4:30PM	Environmental Hazard Prediction Thrust Area Overview
4:30PM-5:00PM	Operations Effects Thrust Area Overview
5:00PM-5:30PM	Battlespace Management Thrust Area Overview
5:30PM	Adjourn for the day
5:30PM-6:30PM	**Reception** *& Joint Project Manager Information Systems Demonstration*

Wednesday, October 26

8:00AM-8:30AM	Registration and Continental Breakfast
8:30AM-8:35AM	Admin Remarks
8:35AM-9:10AM	Agent Fate Program Overview
9:10AM-9:30AM	Decision Support Program Overview
9:30AM-9:50AM	Research Development and Engineering Command (RDECOM) Overview
9:50AM-10:20AM	**Break** *& Joint Project Manager Information Systems Demonstration*
10:20AM-12:00PM	Breakout Session A

Working Group I - Dispersion Modeling and Sensor Data Fusion
Session Chair: John Pace

10:20 AM – 10:50 AM	John Pace	Overview of Hazard Prediction Modeling Program
10:55 AM – 11:25 AM	Paul Thomas	Source Term Estimation Module (STEM)
11:30 AM – 12:00 PM	Ian Griffiths	STEM demo

Working Group II – Chemical Agent Persistence and Prediction Modeling
Session Chair: Mark Fagan

10:20 AM – 10:50 AM	Dr. Arianus R. Hin	Agent Fate Predictive Model Methodology
10:55 AM – 11:25 AM	Dr. Homayun	Agent Fate 1st Principles Modeling
11:30 AM – 12:00 PM	Dr. Evans	Quantum Chem Theoretical Modeling

Working Group III - Battlespace Management
Session Chair: Bill Ginley

10:20 AM – 10:50 AM	Mr. Bill Ginley	Shared COP
10:55 AM – 11:25 AM	Mr. James Reilly	Next Generation CB Battle Management System
11:30 AM – 12:00 PM	Mr. James Reilly	Next Generation CB Battle Management System

Working Group IV - Decision Making and Support
Session Chair: Scott Cahoon

10:20 AM – 10:50 AM	Dr. Jeffrey Grotte	Decision Support Analytical Framework
10:55 AM – 11:25 AM	Mr. Michael Kierzewski, Mr. King	Virtual Prototyping Feasibility/Benefit and CB Common Knowledge Base
11:30 AM – 12:00 PM	Dr. Frank Gilfeather	Chemical and Biological Defense Multivariate Decision Support Tool

Working Group V - Special Topics: Test and Evaluation
Session Chair: Eric Lowenstein

10:20 AM – 10:50 AM	Dr. William Brence	A Quantitative Tool for the Identification, Correlation, and Selection of Chemical Agent Simulants for OT&E; Implications for and Applications to Current and Future Programs
10:55 AM – 11:25 AM	Avidan	MNS/CBRN System Integration

11:30 AM – 12:00 PM	TBD	TBD

12:00PM-1:00PM **Lunch** (On Own)
1:00PM-3:30/5:00PM Breakout Session B

Working Group I - Dispersion Modeling and Sensor Data Fusion
Session Chair: John Pace

1:00 PM – 1:30 PM	Dr. Deborah Fish	Fusion of CB Data and Model Output
1:30 PM – 2:00 PM	Mr. Rick Fry	Chemical/Biological Source Characterization
2:00 PM – 2:30 PM	Mr. Keith Gardner	Optimizing Sensor Placement for CB Defense
2:30 PM – 3:00 PM	Mr. Mike Smith	Sensor Location Optimization Tool Set
3:00 PM – 3:30 PM	Jason Nachamkin	Hazard Prediction with Nowcasting

Working Group II – Special Topics I
Session Chair: Mark Fagan

1:00 PM – 1:30 PM	Mr. Doug Hardy	The Need for CBRN and Medical COI Interoperability and the Proposed Way Forward
1:30 PM – 2:00 PM	Mr. Mark Neff	Providing Capabilities-Based Analysis in Dynamic Operational Environments: Leveraging Integrated Architecture and Use Cases to Define and Deliver Rapid Capabilities
2:00 PM – 2:30 PM	Mr. David Gregory	Chemical and Biological Warfare Modeling Library (CBWLIB)
2:30 PM – 3:00 PM	Mr. Donald McFarlane	Contamination Avoidance at Seaports of Debarkation (CASPOD) ACTD: A Study in the Importance of Early User Involvement During User Interface and System Capabilities Development
3:00 PM – 3:30 PM	Dr. James L. Regens	Advances in Biotechnology and the Biosciences for Warfighter Performance and Protection

Working Group III - Battlespace Management
Session Chair: Bill Ginley

1:00 PM – 1:30 PM	Mr. Patrick Berry	A Bayesian Approach for Assessing Confidence in a Biological Warfare (BW) Detection Event
1:30 PM – 2:00 PM	Mr. Thomas Sanderson	Hyperspectral Mid-Range Toxic Gas Detection System
2:00 PM – 2:30 PM	Dr. Juergen Leonhardt	A New BIO IMS for Simultaneous Detection of CWA Material
2:30 PM – 3:00 PM	Mr. Thomas Sanderson	Multi-Sensor Battlespace Management Architecture
3:30 PM – 4:00 PM	Mr. Steven Streetman	Chem-Bio Protection Without Chem-Bio Sensors: Low Cost, Dual Use Alternative Sensor and Information Architectures

Working Group IV - Decision Making and Support
Session Chair: Scott Cahoon

1:00 PM – 1:30 PM	Mr. Donald McGonigle	The Chemical and Biological Defense Information Analysis Center (CBIAC), a Knowledge Management Source for Authoritative Information
1:30 PM – 2:00 PM	Dr. Rafael Alonso	A Chem-Bio Information System for Rapid Knowledge Acquisition to Support Bio-weapons Countermeasures
2:00 PM – 2:30 PM	Caudell	Flatland Virtual Data Decision Support Tool
2:30 PM – 3:00 PM	Dr. Steve Helmreich	Coordinating CB engagement scenarios with the CBRN
3:00 PM – 3:30 PM	**BREAK**	
3:30 PM – 4:00 PM	Prasad	Data Model Machine Intelligence in Decision-making (MInD) Automated Generation of *CB* Attack Engagement Scenario Variants
4:00 PM – 4:30 PM	Dr. Bill Ogden	Methods for Understanding Human Interface Requirements for Decision Support Tools
4:30 PM – 5:00 PM	Dr. Hung Nguyen	Allocations of Resources in CB Defense: Optimization and Ranking

Working Group V - Special Topics: Test and Evaluation
Session Chair: Eric Lowenstein

1:00 PM – 1:30 PM	Dr. Timothy Shelly	A Distributed Processing Sensor Network for Detect-To-Warn Capability
1:30 PM – 2:00 PM	Dr. Jonathan Davis	Development of Plague Outbreak Decision Tool
2:00 PM – 2:30 PM	Dr. Myron Hohil	Reliable Discrimination of High Explosive and Chemical/Biological Artillery Using Acoustic Sensors
2:30 PM – 3:00 PM	TBD	TBD
3:00 PM – 3:30 PM	**BREAK**	
3:30 PM – 4:00 PM	Dr. Peter Mantica	Infrared Scene Simulation for Chemical Standoff Detection System Evaluation
4:00 PM – 4:30 PM	Dr. Juergen Leonhardt	Neutro Test – A Neutron Based Non-Destructive Device for Finding Hidden Explosives
3:30 PM – 4:00 PM	Dr. Peter Mantica	Infrared Scene Simulation for Chemical Standoff Detection System Evaluation

5:00 PM	Adjourn for the day
5:30 PM	Social Hour
6:30 PM-8:00 PM	CBIS Annual Banquet Guest Speaker Gary Yamamoto “Restore the Passion: For Work and For Life!”

Thursday, October 27

8:00AM-8:30AM **Continental Breakfast**

8:30AM-8:35AM Admin Remarks

8:35AM-10:00AM Breakout Session C

Working Group I - Dispersion Modeling and Sensor Data Fusion
Session Chair: John Pace

8:35 AM – 9:00 AM	Dr. Douglas Burns	An Atmospheric Chemistry Module for Modeling Toxic Industrial Chemicals
9:00 AM – 9:30 AM	Mr. Mike Armistead	Chemical and Biological Hazard Environmental Prediction
9:30 AM – 10:00 PM	Ms. Teri Robertson	Development of a Model for Predicting the Aerosolization of Agents in a Stack

Working Group II – Current Ops Effect S & T Projects
Session Chair: Mark Fagan

8:35 AM – 9:00 AM	Dr. Tom Stark	JOEF Prototype Development
9:00 AM – 9:30 AM	Maj William Greer	Next Generation model Development
9:30 AM – 10:00 PM	Darrell Lochtefeld	Impact Assessment Tool

Working Group III - Battlespace Management
Session Chair: Bill Ginley

8:35 AM – 9:00 AM	Mr. Javad Sedehi	Battlespace Management Field Trip
9:00 AM – 9:30 AM	Mr. Jack Berndt	Engineering NBC-RPM
9:30 AM – 10:00 PM	Mr. David Godso	Net-Ready CBRN Sensors -- The Way Ahead

Working Group IV - Decision Making and Support
Session Chair: Scott Cahoon

8:35 AM – 9:00 AM	Mr. Gregory Chavez	Monotone Measure Theory as a Method for Combining Evidence in Threat Engagements
9:00 AM – 9:30 AM	Dr. Panaiotis	Algorithmically Generated Music Enhances VR Decision Support Tool
9:30 AM – 10:00 PM	Dr. Roshan Rammohan	Exploring Optimization Methodologies for Systematic Identification of Optimal Defense Measures For Mitigating *CB* Attacks

Working Group V - Special Topics: Test and Evaluation
Session Chair: Eric Lowenstein

8:35 AM – 9:00 AM	Mr. Peter Mantica	Active Standoff Chemical Detection Model for System Studies
9:00 AM – 9:30 AM	Mr. William Snee	Phased Data Model Implementation Approach
9:30 AM – 10:00 PM	Dr. George Thompson	Chemical Homeland Security System (C-HoSS)

10:00AM-10:30AM **Break** *& Joint Project Manager Information Systems Demonstration (Last Chance to view Demo)*
10:30AM-12:00PM Breakout Session C Continued

Working Group I - Dispersion Modeling and Sensor Data Fusion
Session Chair: John Pace

10:30 AM – 11:00 AM	Julie Pullen	Coupled Air-Sea Modeling for Improved Coastal Urban Dispersion Prediction
11:00 AM – 11:30 AM	Rob Marshall	Measurement of Coastal & Littoral Toxic Material Tracer Dispersion
11:30 AM – 12:00 PM	John Hannan	Intercomparison of Four Rockle-Based Urban Dispersion Models

Working Group II – Special Topics II
Session Chair: Mark Fagan

10:30 AM – 11:00 AM	Maj Greer	CHEMRAT and AFMAN 10-2602 Persistence Modeling
11:00 AM – 11:30 AM	Tim Gaughan	CB System Military Worth Assessment Toolkit
11:30 AM – 12:00 PM	Dr. Gene McClellan	Predictive Models for Chem-Bio Human Response, Casualty Estimation and Patient Loads

Working Group III - Battlespace Management
Session Chair: Bill Ginley

10:30 AM – 11:00 AM	Mr. Joshua Pressnell	Wirelessly Enabling Legacy Sensor Systems for Rapid Deployment and Monitoring
11:00 AM – 11:30 AM	Mr. Thomas Sanderson	Performance Quality Monitoring Architecture for Sensor Networks
11:30 AM – 12:00 PM	TBD	

Working Group IV - Decision Making and Support
Session Chair: Scott Cahoon

10:30 AM – 12:00 PM	Dr. Frank Gilfeather	Multivariate Decision Support Tool Set-up

Working Group V - Special Topics: Test and Evaluation
Session Chair: Eric Lowenstein

10:30 AM – 11:00 AM		Program Decision Issues
11:00 AM – 11:30 AM		Program Decision Issues
11:30 AM – 12:00 PM		Program Decision Issues

12:00PM-1:30PM **Lunch (On your own)**

1:30PM-3:30PM Breakout Session D (and concurrent Executive Session)

Working Group I - Dispersion Modeling and Sensor Data Fusion
Session Chair: John Pace

1:30 PM – 2:00 PM	Theo Theofanous	Release and Atmospheric Dispersal of Liquid Agents
2:00 PM – 2:30 PM	Dr. Jeffrey Peterson	Modeling and Simulation to Support Virtual Chemical Hazard Environments
2:30 PM – 3:00 PM	Dr. Steve Warner	Translation of JEM Accuracy Requirement into a Measurable Acceptability Criterion

Working Group II - Operations Effects Modeling
Session Chair: Mark Fagan

1:30 PM – 2:00 PM	Mr. Keith Gardner	Combined Defense Model
2:00 PM – 2:30 PM	Dr. Shanna Collie	Health Effects Decision Support Tool for Civilian CB Air and Water Attack Squadron
2:30 PM – 3:00 PM	Mr. Scott Milburn	Employing Military Virtual Reality Simulation Technology to Train for Prevention, Deterrence, Response, and Recovery for Chem Bio Events

Working Group III - Battlespace Management
Session Chair: Bill Ginley

1:30 PM – 2:00 PM		Program Decision Issues
2:00 PM – 2:30 PM		Program Decision Issues
2:30 PM – 3:00 PM		Program Decision Issues

Working Group IV - Decision Making and Support
Session Chair: Scott Cahoon

1:30 PM – 3:30 PM	Cahoon, Gilfeather	Presentation of Chemical and Biological Defense Multivariate Decision Support Tool to Dr. Charles Gallaway

Working Group V - Special Topics: Program Decision Issues
Session Chair: Eric Lowenstein

1:30 PM – 3:30 PM		Program Decision Issues
2:00 PM – 2:30 PM		Program Decision Issues
2:30 PM – 3:00 PM		Program Decision Issues

3:30PM **Conference Adjourns**

***********Following for JPM IS personnel, JSTO personnel and Session Chairs********************

4:00PM-5:00PM Hotwash and Summary from Working Group Chairs

5:00PM Adjourn for the day

Friday, October 28

8:00AM-8:30AM **Continental Breakfast**

8:30AM-10:00AM Executive Session

10:00AM Conference Adjourns

WARNING, THE CRITICAL ELEMENT TO MITIGATE THE EFFECTS OF A CBRN ATTACK

Dr. Alan Avidan
MadahCom, Inc., 7565 Commerce Court, Sarasota, FL 34243
Alan.avidan@madah.com

Science and Technology for Chem-Bio Information Systems
Topic: Decision Making Support - Human Effects

MNS/CBRN System Integration

Abstract
Mass casualties are to be expected upon use of Chemical and biological weapons against military and civilian targets. To effectively mitigate the threat, an integrated detection—alerting system is required. MadahCom, Inc. has produced an effective integrated MNS-CBRN system that is able to provide the right message, to the right people, at the right time, and hence minimize the number of casualties before, during and after an attack. The system is also able to provide event notification up the command chain by integrating with Command and Control (C2) systems for improved situation awareness.

Introduction

The worldwide proliferation of chemical, biological, radiological and nuclear weapons capabilities, as heightened by recent events, has broadened the range of scenarios in which use of these threats is possible. Mass casualties is now the expected normal outcome from use of these weapons when used against military and civilian population concentrations.

Whereas the detection of the CBRN threats is necessary to in order to generate timely alerts, detection is insufficient, by itself, to save lives, mitigate casualties and minimize chaos. It is the actual warning of personnel in the effected areas, and the take-action instructions provided to them in a timely and coordinated manner that is equally critical a part in an overall effective mitigation response. Not unlike natural disasters, such as a tsunami, hurricane, or earthquake detection alone can not be effective without properly dissemination of this information.

Warning the public of an impending attack is obviously not a new tactic. Consider the midnight ride of Paul Revere as a historical example of using both an audible and visual alerting method. In April 1775, Revere hung two lanterns in the bell-tower of Christ Church in Boston, indicating from pre-planned signals that the British troops would row “by sea” rather than marching “by land.” He then alarmed the country-side by riding and stopping at each house.

Alerting has certainly come a long way since 1775. In today's world being prepared is even more critical than ever. And being able to quickly detect and identify such new threats as Anthrax, Sarin and Ricin, to name but a few, has become a necessity. As detection speed and accuracy increased, the need as well as the value of a more immediate alerting. Yet alerting technology has languished, often requiring a "person-in-the-loop" to create a response (often called the 'swivel-chair solution'). Manual activation of alerting scenarios often created difficulties of delayed activation, errors in following procedures, and, in general, chaotic over-reaction.

The ramifications of delayed alerting (or no alerting at all) are rather obvious. What is less obvious are the consequences of producing warnings that are not clear, or ones that are distributed too widely and cause an interruption to personnel that will not be affected by the threat and do not need to know. One can imagine being a soldier in a war zone, being awakened every hour, or so, by an alarm that may effect the general area, but that has no impact on his/her immediate location. After a few such unnecessary ["false"] alarms, one may be inclined not to respond to the next warning, which, clearly, can be a tragic mistake. False or indiscriminate alarms in buildings and areas not under immediate threat places more people in harm's way, and result in a poorly managed emergency scenario.

What is a Mass Notification System?

To reduce the risk of mass casualties there must be a timely means of notifying personnel in buildings and outdoor environments of threats and what should be done in response to those threats. Specific, well-directed, pre-recorded and live voice emergency messaging are the key ingredients of such notifications. Mass Notification Systems (MNS) are designed to inform and instruct personnel within protected areas, in real-time, what to do in cases of threats.

Available Technologies for Mass Notification

From historic emergency notification methods such as flags, bells and smoke signals to yesterday's methods of sirens (tones) and fire bells, alerting has evolved significantly. Due to current complex threats like a chemical attack, voice is important for specific instructions. When warning times are short or nonexistent, the message becomes even more critical. Today's MNS provides effective means of audible (speaker towers and indoor/outdoor speakers) and visual alerting (LED signs and strobes). An integrated MNS may contain some or all of the following components - base-wide control systems, individual building systems, outdoor systems, telephone notification systems and a network of alert sensors.

Fire protection systems are often considered a component of a MNS (but never a replacement).

Base-Wide Control System

Implementation of a base-wide mass notification system offers the advantages of centralized control, monitoring and message delivery. Base-wide control systems are a critical ingredient of an effective MNS; it leverages the 24/7 availability of professional emergency management resources in command posts and law-enforcement-dispatch centers to instantly notify personnel throughout the base of an imminent threat. As such, base-wide systems complements individual building systems that are primarily used for local emergency event management, but are not always staffed with properly trained personnel.

Base-wide systems may be implemented as wired or wireless systems. Wireless systems increase the survivability of the entire MNS by increasing the communication reliability among

the various system components. Wireless systems also offer significant cost advantages where wide-area coverage is desired.

Automated Responses to Events

Sophisticated mass notification systems, such as MadahCom's WAVES, offer programmed (scripted) responses to events. The activation of an alert sensor, be it a pushbutton at a gate, a wireless "panic" button or a CBRNE detector, may be programmed to trigger notifications without further intervention of a human operator, thereby decreasing response time and the likelihood of notification failures.

Remote Activation

An effective MNS must provide command and force protection personnel with the ability to remotely access the base-wide control system and activate critical mass notification functions. This can be done using the telephone (including cellular) or a computer, a networked computer as well as wired/or wireless activators.

Individual Building Systems

An individual building system consists of an Autonomous Control Unit (ACU) driving a network of notification appliances.

An ACU is used to control and monitor the notification appliance network as well as provide consoles for local operation. Using a console, personnel in the building can initiate delivery of pre-recorded voice messages and provide live voice messages and instructions. To avoid confusion caused by the simultaneous activation of a fire alarm, UFC mandates that the MNS temporarily deactivate audible fire alarm notification appliances while delivering voice messages. The ACU communicates with the base-wide system to provide status information and receive commands and messages.

The notification appliance network consists of audio speakers placed to provide intelligible instructions at locations in and around the building. Other devices such as strobes and LED displays may be provided to alert hearing-impaired personnel, as appropriate.

In a variety of cases, the use of speakers and other components of an existing public address system may be appropriate in buildings where the installation of a new speaker system is not cost-effective. If this implementation approach is taken, an individual building mass notification system may be interfaced with an existing public address system. Features are provided by the MNS to ensure that emergency messages have priority over non-emergency messages.

Giant Voice Outdoor Systems

The Giant Voice system is typically installed as a base-wide system to provide siren signals, pre-recorded and live voice messages. It is most useful in providing mass notification for personnel in outdoor areas, expeditionary structures, and temporary buildings. It is generally not suitable for mass notification to personnel in permanent structures because of the difficulty in achieving acceptable intelligibility of voice messages.

A base-wide mass notification system that incorporates both a Giant Voice sub-system and individual, indoor building systems provides the user better protection.

Telephone Notification Systems

Telephone alerting systems are independent systems that may be used to provide notification primarily to key personnel that are off-site. These systems should not be used for the purpose of reaching large number of people due to capacity limitations. It is also important to note that these systems generally rely on external infrastructure systems not in the control of the facility (such as land-line and cellular telephone systems).

MNS Advanced Technology

MadahCom, Inc., a recognized leader in providing Anti-Terrorism/Force Protection (AT/FP) for military bases worldwide, provides digital wireless emergency notification systems. MadahCom's WAVES (Wireless Audio Visual Emergency System) and its portable system, TACWAVES (Tactical WAVES), are stand-alone, integrated alerting and site protection systems. When combined with CBRN Sensors both systems provide a formidable component of the Force Protection needs for Bases, Expeditionary Units and Tent Cities. WAVES provides control of live and automated both indoor and outdoor, audio and visual warnings and instructions in emergency situations. By the use of strobes and LED (indoor & outdoor) signs, messages can be sent out when needed in areas that have audio problems (i.e. hangars, loud noise environments, etc).

Developed using secure wireless technology, a digital wireless MNS like MadahCom's WAVES is highly survivable and can successfully operate in severe electronic countermeasure environments. Secure digital Frequency Hopping Spread Spectrum (FHSS) technology and "a redundancy backbone" are incorporated in the system design, preventing jamming, and interference, eavesdropping, and spoofing as well as protecting the network in the event of a disaster. FHSS operation disperses the transmission over a large bandwidth, minimizes the possibility of any interference, and is virtually jam proof, even against the most sophisticated state-of-art jammers. This includes high power broadband jammers as well as jammers that attempt to detect the frequency hopping sequence using spectral analysis.

It can operate as a stand-alone system or be integrated with security systems such as intrusion detection, access control, fire alarms, as well as CBRNE detection systems. However, the only MNS that fully integrates with a CBRN detection system is WAVES. This integration is crucial for the following reasons:

1. Saving civilian and soldiers' lives
2. Minimizing casualties of personnel who check the detection equipment
3. Integrating plume propagation into the equation in order to give specific instructions to specific zones
4. Automatically instructing zone/areas where people only have seconds to respond
5. Alerting on a City/County-wide level

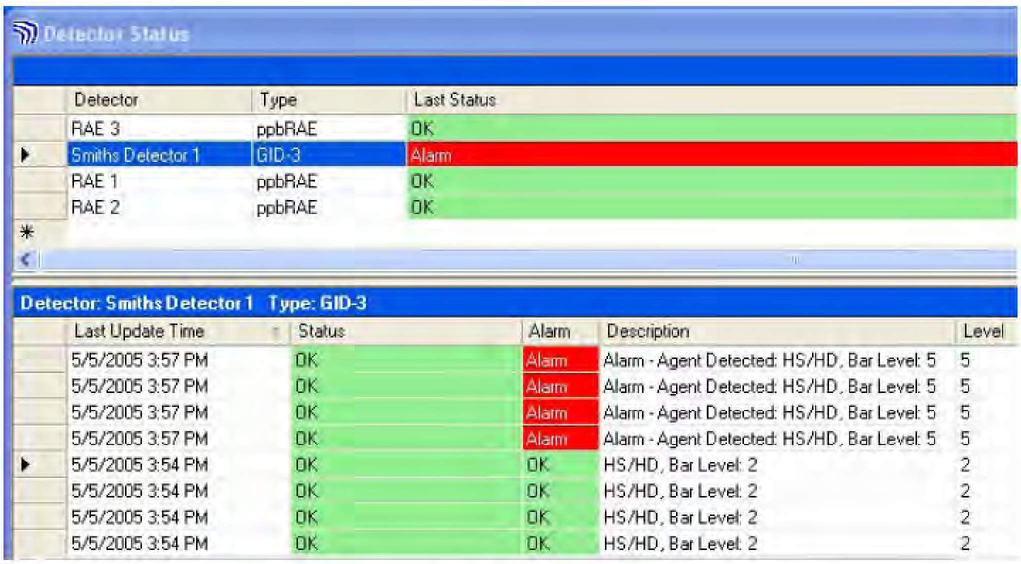
Integration of Mass Notification System (MNS) with CBRN Sensors

A well integrated MNS—CBRN detection system helps protect people in case of an attack. Before an attack, available information can be effectively disseminated via the MNS and directed by zone to the affected areas instructing personnel to take pre-attack mitigating actions. Once the threat is detected, specific warnings and take-action instructions are immediately distributed to the affected, or soon to be affected, zones providing personnel maximum time to take actions that minimize the brunt of the attack, minimizing casualties. After an attack, information can be disseminated that can help recovery efforts and restore operations.

When a chemical or biological agent is detected by the sensor(s), the sensor immediately sends the data to the WAVES MNS Field Transceiver, which, in turn, sends the data within several tens of milliseconds to the MNS central base station. At the central base station the incoming data is compared with a pre-set look-up database to determine the alarm levels. The WAVES MNS central base station display shows an alarm status, as well as information about the detected agent, and its relative concentration. Emergency alarms are triggered when concentration levels high enough to merit an alarm. In the example below, the screen shows detection of the chemical HS/HD and the time history of exceeding the pre-set emergency alarm level of 3. On its second screen (not shown) the WAVES MNS shows the alarm location with a blinking icon on its digital map display. A pop-up message next to the blinking icon shows the alarm level, the triggering agent plus additional details about the readings.

In addition, The WAVES MNS can respond based on pre-determined parametric scripts and automatically send pre-recorded voice and text messages to loudspeakers and LED/Strobe signage in the affected areas. For example, the message: "Alarm Yellow… Take Cover! …Don

Gas Masks & Chemical Defense Gear!" can be played in the immediately affected areas. The message is normally preceded by alarm tones and is repeated several times. The person in charge in the emergency operation center can manually override the message and send out a live or another pre-recorded message after examining the data. Other messages can also be automatically or manually sent to other areas (zones) advising personnel to either evacuate, take protective actions or do nothing, as the conditions warrant. The above described scenario is only one particular response type; the flexibility of the WAVES MNS allows for numerous pre-scripted response scenarios that can be further changed at any time thereafter by the system administrator.



Smith Detector Event Gas Type and Concentrations

Integration of Plume Propagation Models

By adding a plume propagation model, and by adding a GIS location-aware capability (GeoSmart™) to the wireless transceivers, the MNS can be programmed to automatically send different messages to different zones based on the plume propagation model's predictions. This feature can significantly improve the effectiveness of the overall CBRN attack response by minimizing chaos and consequently casualties. Depending on the plume propagation prediction, personnel in specific areas may be instructed to stay in a building and take protective actions or evacuate to a safer area if time allows.

In the industrial example below, the security command center at plant XYZ sends out four specific voice/visual instructions to the different zones. The voice messages are preceded by alarm tones, and the visual text messages are preceded by flashing strobe signals in order to get immediate attention:

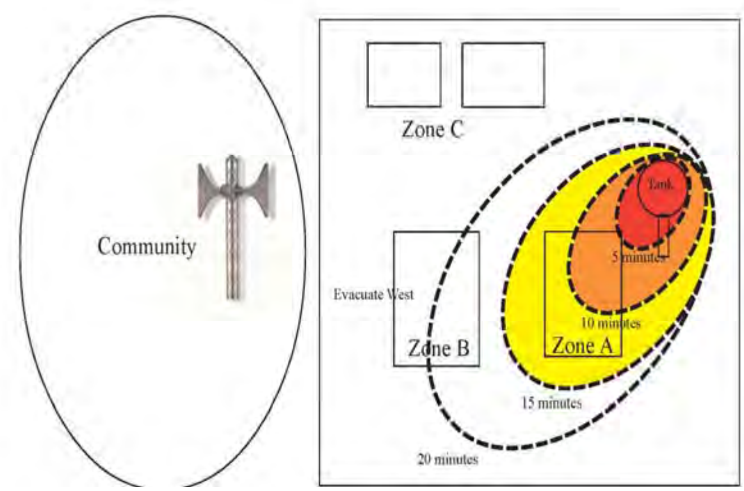
Zone A Message:
"This is Security. There has been a Chlorine tank explosion in the plant. You are in the danger zone. Do not leave the building. Immediately take the following actions: Close and seal all windows and doors by placing wet clothes around them. Turn off the air conditioning system and

any stand-alone air conditioning units. Repeat – Do not leave the building! Await further instructions from Security."

Zone B Message:
"This is Security. There has been a Chlorine tank explosion in the plant. Immediately evacuate the building by exiting only through the West doors and head to the assembly area in Parking Garage C. Repeat – Immediately evacuate the building through the West doors to Parking lot C."

Zone C Message:
"This is Security. There has been a Chlorine tank explosion in the plant. You are not in the danger zone. Please remain in the building until further notice. Take the following precautions: turn off the air conditioning system and close all windows and doors. Do not leave the building until further notice. Await further instructions from Security."

Message to the Community: (over high powered speaker-sirens)
"Your attention please: there has been a Chlorine release at Plant XYZ. You are not in the immediate danger Zone. However, please remain indoors until further notice. Please remain calm and await further information from authorities."



The GeoSmart™ capability allows the WAVES MNS to determine which of its units are within an area determined by a geographical criterion (such as determined by a plume propagation model) and automatically assemble announcement zones on an ad-hoc basis. This feature is called AutoZoneAlert™ and is an especially powerful feature when warning times are very short and the detected threat is bound to affect areas that do not conform to pre-zoned layouts. Hence, information received either directly from detectors or indirectly via a host Command and Control (C2) system can be parlayed into relevant emergency alerting announcement within seconds of threat detection. Whether a CBRN attack, a HAZMAT spill, perimeter breach or incoming munitions, the WAVES MNS can effectively issue alerting messages that are specific to the threat, specific to the area affected, and in real-time.

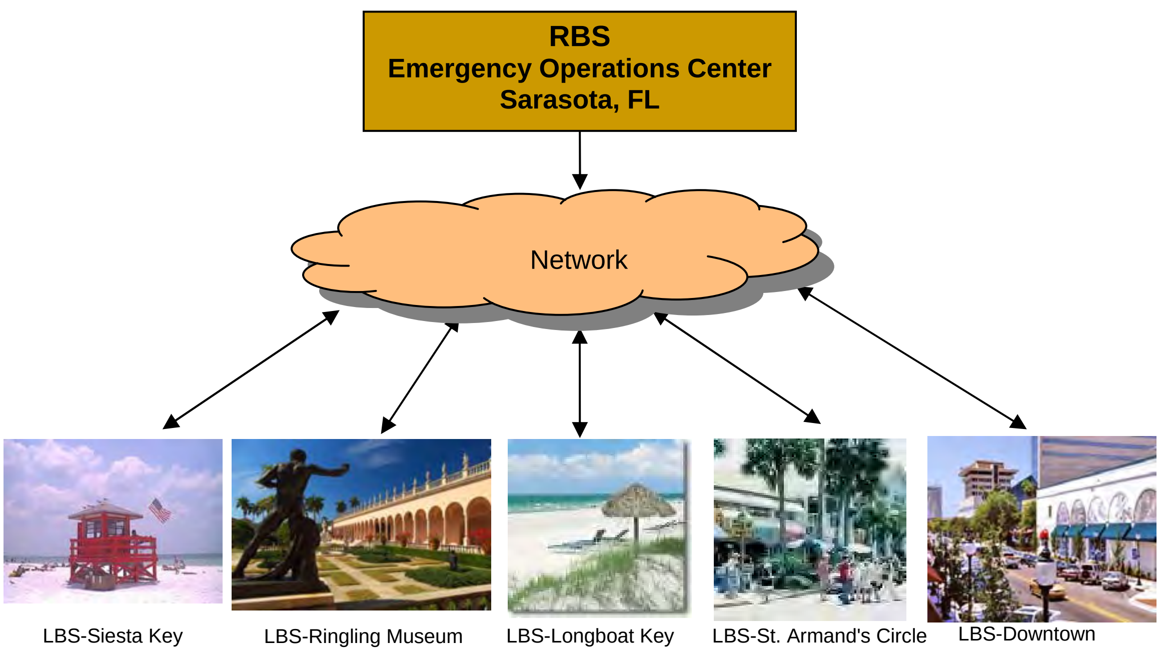
Wide-Area Alerting

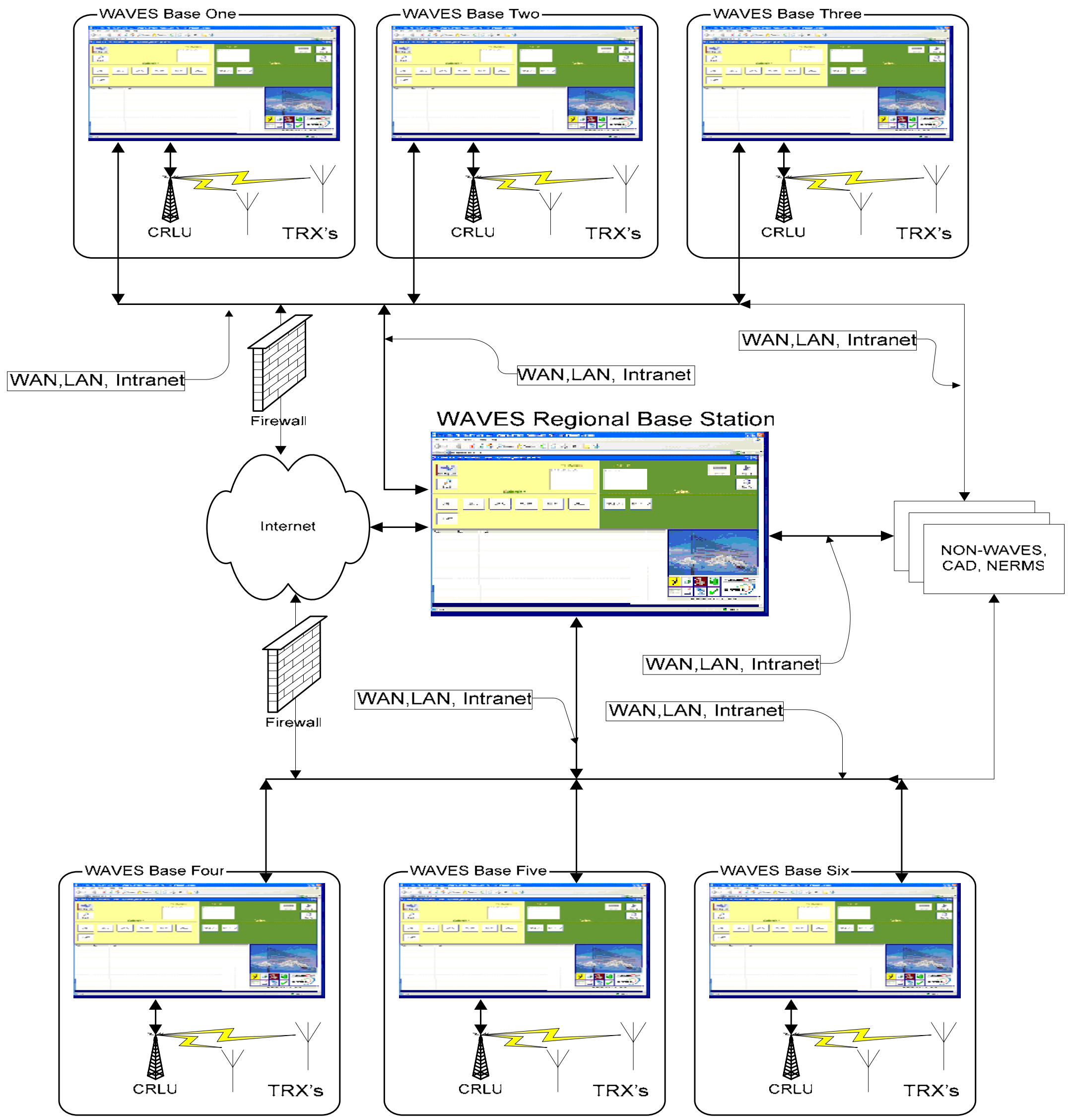
Often, CBRN threats may encompass entire communities. The WAVES MNS is capable of assembling multiple local, geographically separated MNS sites into a broader regionally controlled system. The MNS Local Base Stations (LBS) are connected via LAN, WAN, Intranet or Internet to create a wide area coordinated alerting and monitoring network, expandable to essentially any scale.

The WAVES MNS Regional Base Station (RBS) would normally be placed in regional command center in a military setting, or in the emergency operations center in a city, county or state. The entire regional system can be controlled from any remote location via a zero footprint GUI such as Internet Explorer running on a laptop computer or PDA. Standard roles and privileges security measures are used to authorize access to the system. The individual LBSs continue to operate independently with local inputs; however, based on pre-defined privileges, they accept and execute RBS commands; they also provide status reporting to the associated RBS server.

External interfaces are also provided for non-WAVES applications. Both the LBS and the RBS can accept XML messages via Socket, file transfer, or serial communication ports to execute WAVES scripts. This enables integration with external C2 systems and Computer-Aided Dispatch (CAD) Systems.

In the example below, an RBS is shown to connect multiple local LBS placed in different parts of Sarasota County, Florida. The regional structure is also shown schematically in the diagram following.





CONCLUSIONS

An effective real-time alerting and warning action, in response to a CBRN attack, can be generated by an "intelligent" parametric Mass Notification System (MNS) tightly integrated with CBRN sensors. A detection, decision, and alerting model must be employed to successfully produce the desired result. The decision element (what's detected, who to alert and when) can be done locally by the MNS, a regional MNS, or externally by a Command and Control (C2) system connected with the MNS system through an IP network.

An effective response can be characterized as one getting **the right message, to the right people, at the right time**. The use of a secure (jam-proof, spoof-proof) communication environment is strongly recommended to assure high reliability of communications links critical in assuring

system response and prevention of hostile counter-effect actions. An effective response can significantly improve readiness, reduce casualties and decrease chaos.

The *right message* is one that is event–specific (i.e., informs people of the specific danger detected, and instructs them what to do (and what not to do), using clear voice and when appropriate visual means such as LED signs.)

To the *right people*, implies being able to automatically direct the correct alerting messages to the affected areas (zones). Targeted zones can be pre-determined based on a-priori scripts, or assembled ad-hoc based on a momentary assessment and propagation direction of the threat and location-aware field alerting units. It is often equally important to prevent alerting in unaffected areas or to advise unaffected areas not to respond.

Acting at the *right time* implies being able respond instantly upon detection when needed, or when most appropriate under some criterion (e.g., staged zone alerting that can minimize chaos).

A Bayesian Approach for Assessing Confidence in a Biological Warfare (BW) Detection Event

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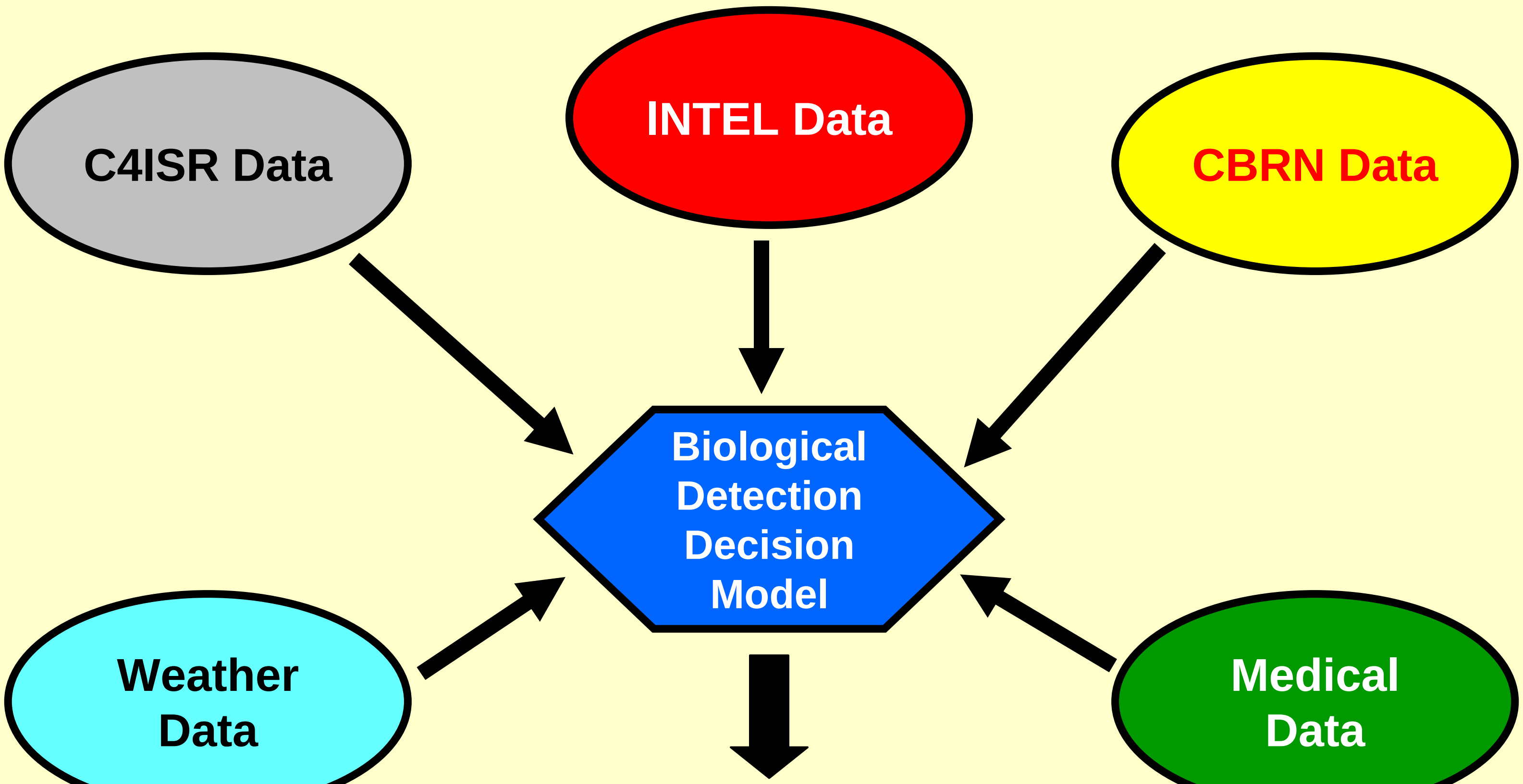
Background

- BW detection challenges
  - Diversity of potential agents
  - Very low effective concentrations
  - Many properties in common with natural background constituents, present in much higher concentrations
- Reliability of results
  - Most current technologies lack high specificity
  - Fielded systems incorporate multiple technologies and/or arrays
- Reliability can be further enhanced by fusing multiple detection results with other BW attack indicators

OBJECTIVE – Present conceptual Bio Detection Decision Model to stimulate application development

Biological Detection Decision Model

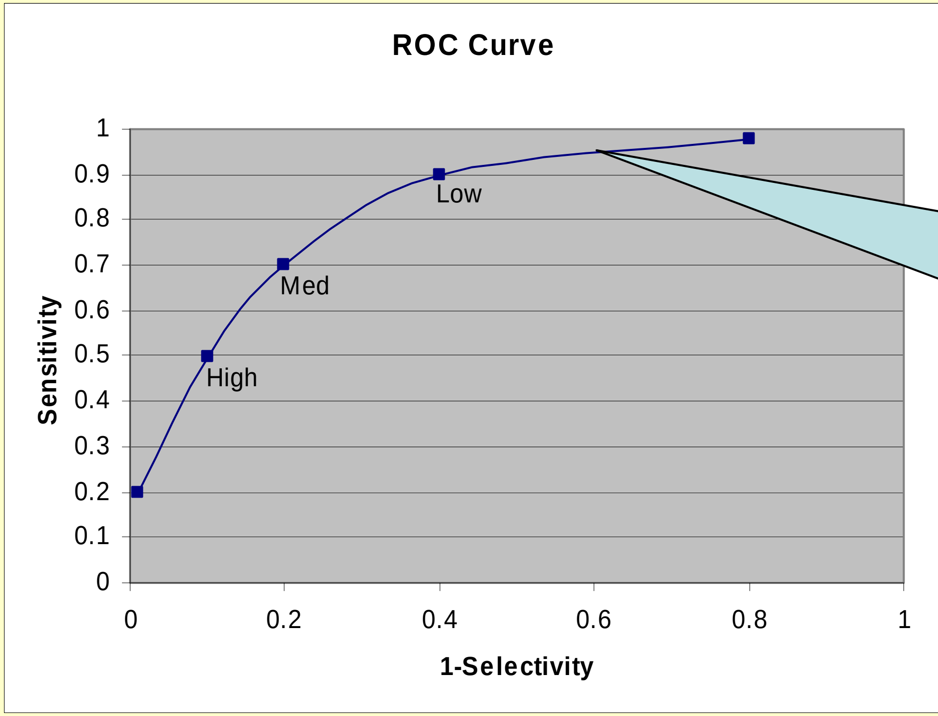


Pr (BW | Evidence) = Probability that a BW attack has occurred given all available information

Key Decision Model Elements

- Detector Performance
  - Receiver Operating Characteristic (ROC) curves
- Decentralized Observations
  - Geographic Areas of Interest (AOI)
  - Valid Time Intervals
- Decision Methodology
  - Bayesian Belief Network → Pr (BW | Evidence)

Receiver Operating Characteristic (ROC)



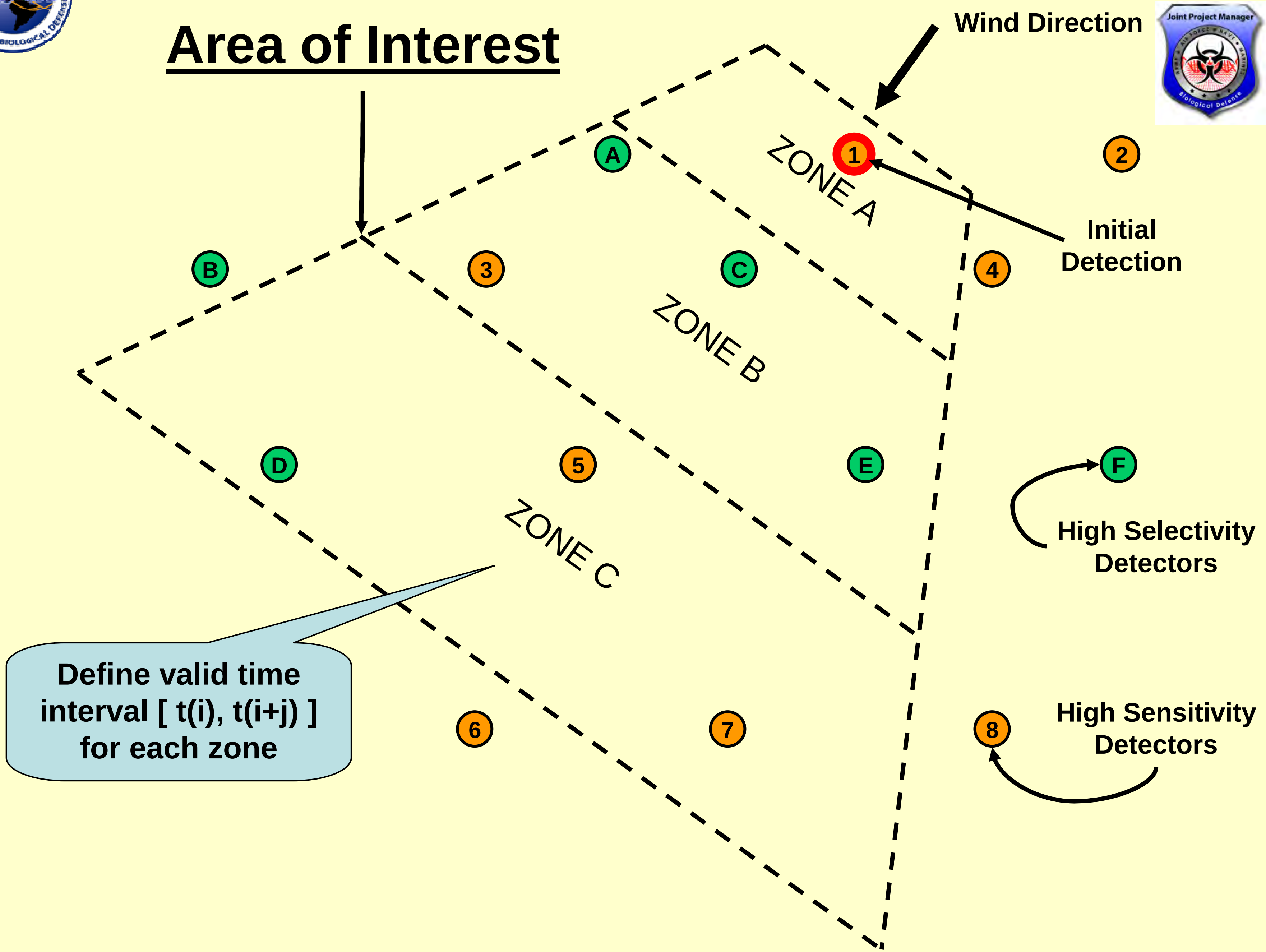
Each ROC curve is a function of response time, agent and background conditions; a detector is represented by a family of such curves

Sensitivity = Pr (Det|BW) = TP/(TP+FN)
Selectivity = Pr (~Det|~BW) = TN/(TN+FP)

Threshold	Sensitivity	Selectivity
Low	0.9	0.6
Medium	0.7	0.8
High	0.5	0.9

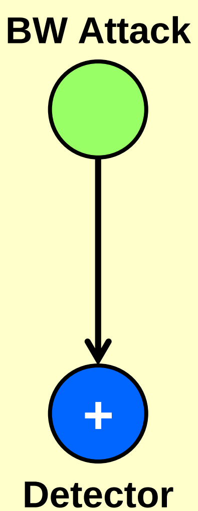
Sensitivity & Selectivity can be computed from performance data, but what we really want to know is Pr (BW|Det) or Pr (~BW|~Det)

Area of Interest



Bayesian Networks

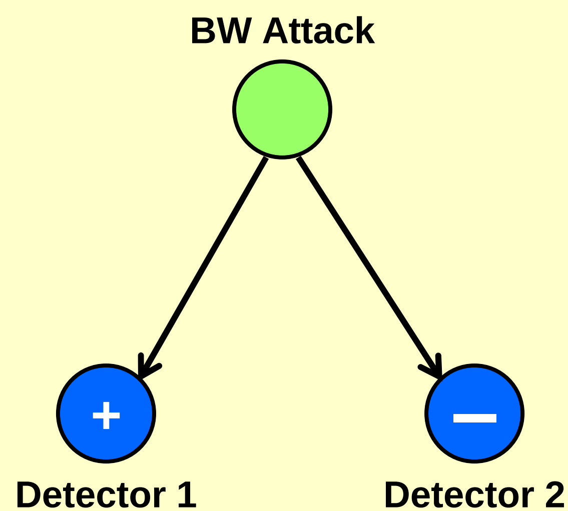
1-Detector Network



Pr (BW) = 0.5
Pr (BW | Det) = 0.74

Pr (Det | BW) = 0.9
Pr (~Det | ~BW) = 0.6

2-Detector Network



Pr (BW) = 0.5
Pr (BW | Det1,~Det2) = 0.58

Pr (Det | BW) = 0.9
Pr (~Det | ~BW) = 0.6

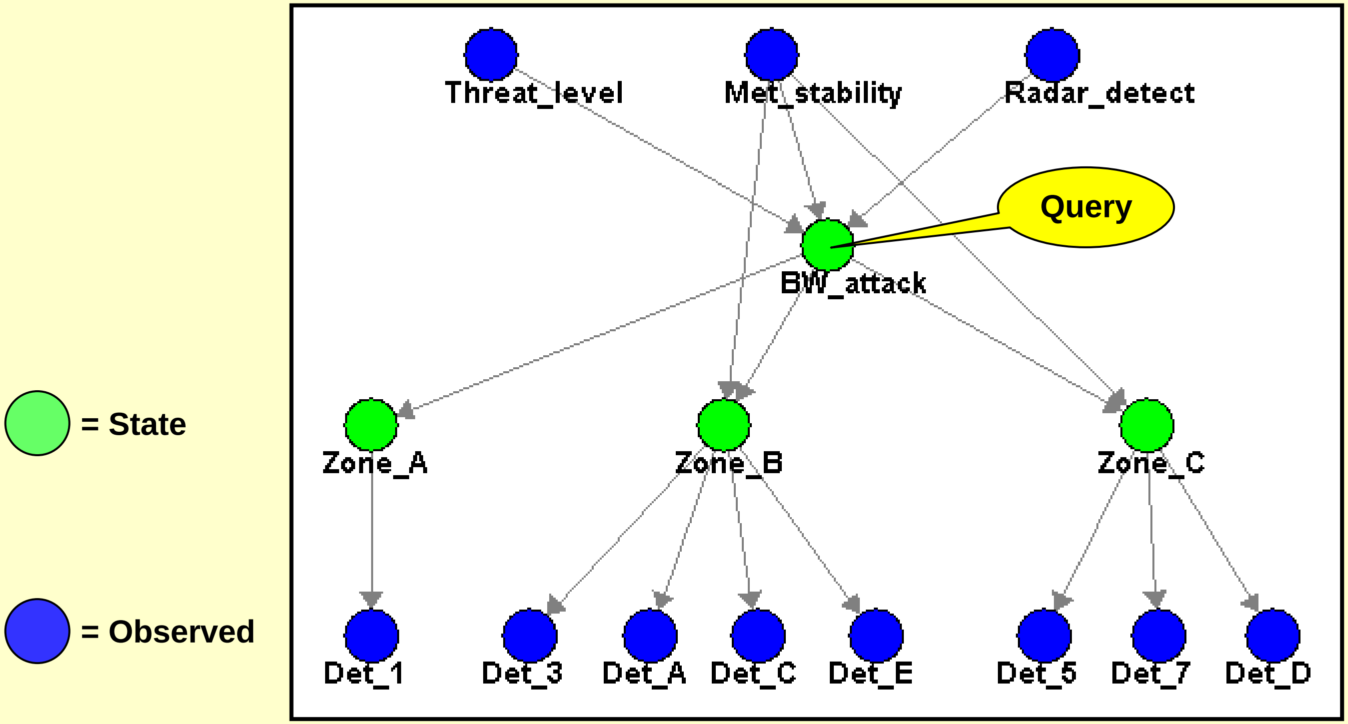
- Prior probability (yellow)
- Posterior probability (pink)
- State variable (green)
- Observed variable (blue)

Directed Acyclic Graph:	Node = random variable
	Arc = probabilistic correlation
Discrete Variables:	Observed = known, State = unknown
Inference by Bayes' Rule:	Pr (B|A) = Pr (A|B) x Pr (B) / Pr (A)

Advantages of Bayesian Networks

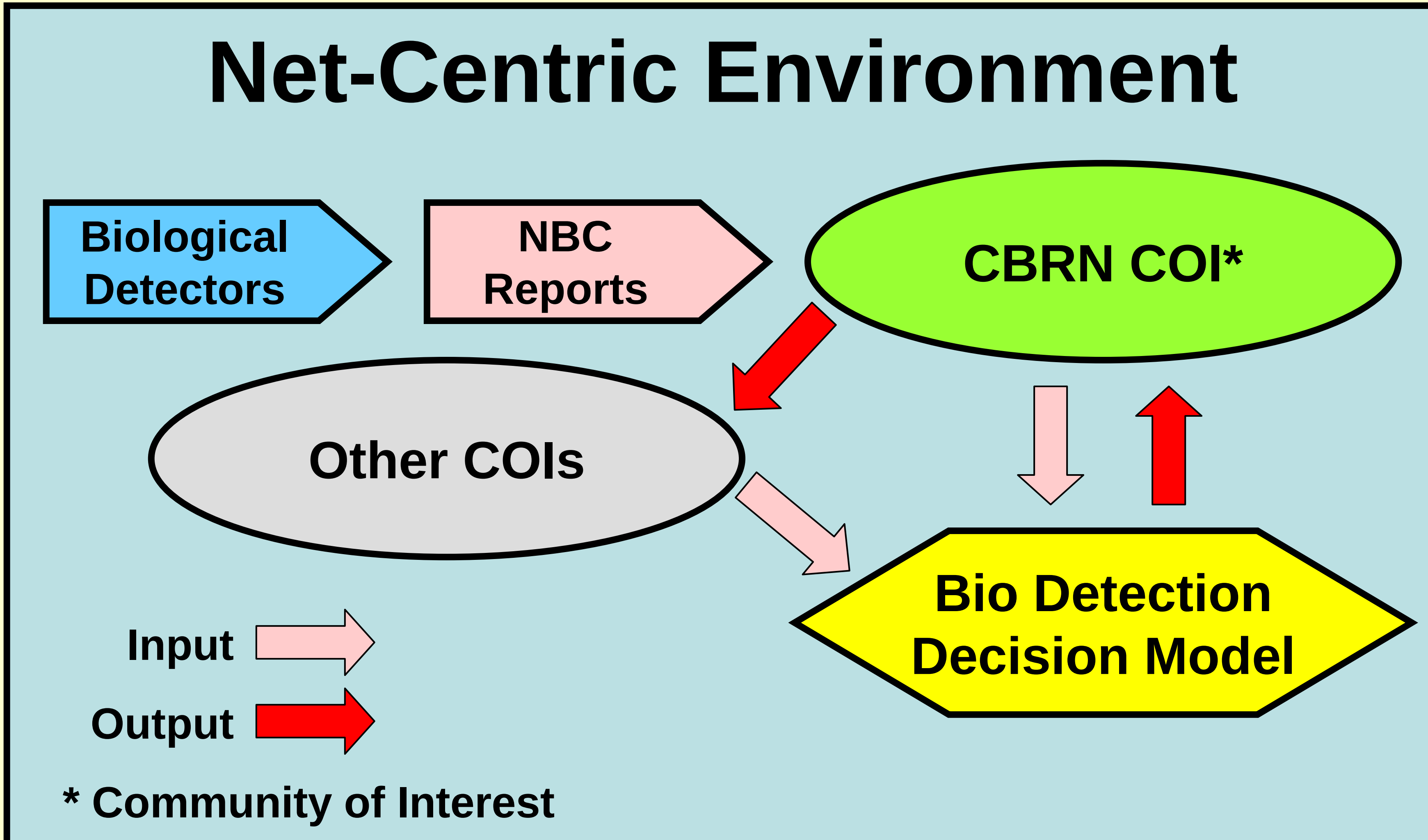
- Provide a means to decompose a joint probability distribution into a set of local distributions
  - Model structure independent from quantification of conditional probabilities
    - Nodes → Pertinent Variables
    - Arcs → Linkages (Dependencies)
  - Only local distributions require quantification
    - Subjective beliefs and discrete or continuous probabilities can be used
    - Efficient inference algorithms guarantee computation of joint distribution
- Successfully applied to diverse military applications
  - Unmanned Underwater Vehicle control system
  - Ship anti-torpedo and anti-missile defense systems
  - Mine detection
  - Ground/air target tracking
  - Commander’s decision aids

Bayesian Network Model



BW Attack Indicators	Positive Detections	Pr (BW | Evidence)
Threat_level = Moderate Met_stability = Neutral Radar_detect = Aircraft	None	0.02
	Det_1	0.53
	Det_1, Det_3 & Det_A	0.96

Biological Detection Information Flow



Conclusions

- Bayesian Networks provide the basis for a coherent biological detection decision model
  - Effectively fuse prior beliefs and probabilities with diverse detector and battlefield observations
  - Provide numerical probability that a BW attack has occurred
  - Substantially increase reliability of generic BW detectors
  - Provide IPB decision tool for allocation and placement of BW detection assets
- Areas for further investigation
  - Identification of all pertinent variables and linkages
  - Methodology to account for spatial and temporal dispersion of detector results
  - Application of likelihood methods for agent classification or identification

CBDP Decision Support Tools and Methodologies

Mr. Scott Cahoon

October 26, 2005

CB Decision Support Tools and Methodologies – In the Beginning

CB Decision Support Tools and Methodologies – The IDA Epoch

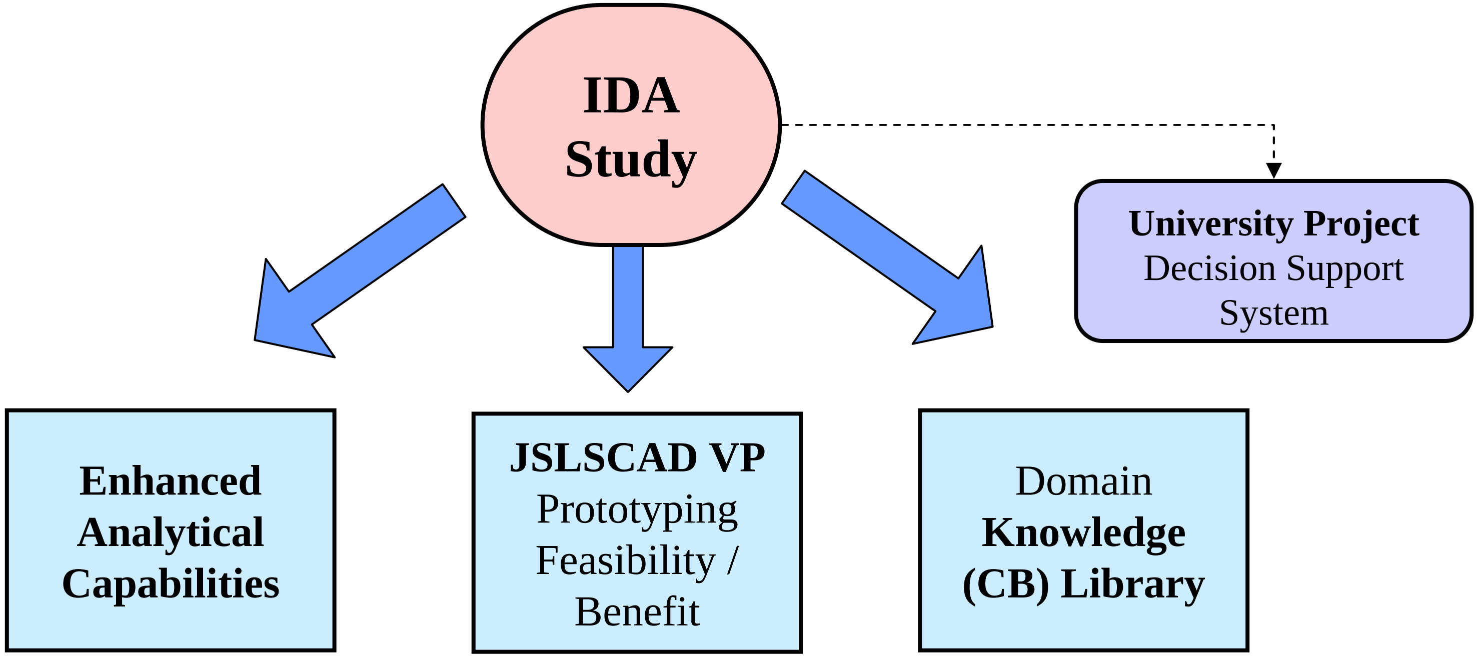
CB Decision Support Tools and Methodologies – The IDA Study Recommendations

- Proactive consumers of CB analysis
- Cadre of trained military and civilian analysts who are prepared to address the issues
- Center of this activity must reside in centralized location
- Technical CB library dealing with weapon effects technology, common models, community communications
- Spectrum of enhanced analytical capabilities to address evolving CB issues

CB Decision Support Tools and Methodologies – The Roadmap

- Formulate a program of studies
- Define/explore options to develop a technical CB library that captures environmental and CBD system performance models
- Initiate efforts to enhance analytical capabilities

CB Decision Support Tools and Methodologies Thrust Area Assessment

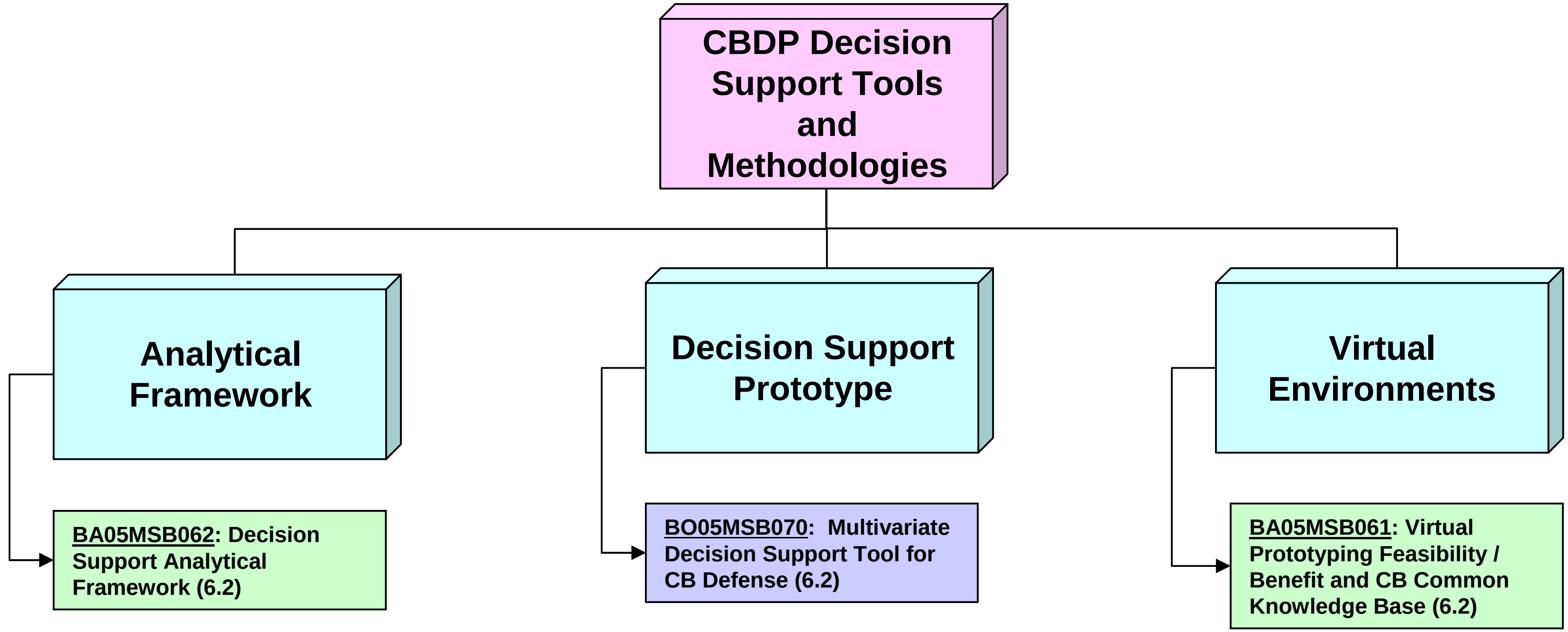


Modeling & Simulation / Battlespace Capability Area Breakdown

M&S / Battlespace Capability Area

- **CB Defense Battlespace Management**
  - Integration of relevant data with C4ISR systems
  - Automated decision aids
  - Sensor data integration
  - → JWARN Joint Warning and Reporting Network
- **CB Warfare Hazard Environment Prediction**
  - Advanced transport & dispersion
  - High altitude dispersion
  - Coastal & littoral
  - Urban dispersion
  - → JEM
- **CB Warfare Effects on Operations**
  - Fixed facility
  - Mobile forces
  - Theater conflict simulation
  - Vulnerability analysis
  - → JOEF
- **CBDP Decision Support Tools and Methodologies**
  - Research, development and acquisition applications
  - Program decision support
  - Virtual prototypes
  - → CBDP

CB Decision Support Tools and Methodologies Thrust Area Taxonomy



CB Decision Support Tools and Methodologies Thrust Area Highlights

- **Rapid analysis capability**
  - **Dial-in threat scenario**
  - **Gather and input data**
  - **Rapid baselining**
  - **Identify gap you are addressing**
  - **Multi-variate analysis tool**
- **Common methodology and metrics for determining success and/or failure of CBDP tools and systems**
- **CBDP knowledge management**
- **Role of virtual prototyping / virtual environments**
- **Transition of simulation tools**

Questions?

Making the World Safer

Back-up Slides

Acronyms and Definitions

- **CBDP (CB)** – Chemical Biological Defense Program
- **C4ISR** - Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance
- **CBR** – Chemical, Biological, Radiological
- **COTS** – Commercial Off-The-Shelf
- **DTRA/ASCO** – Defense Threat Reduction Agency / Advanced Systems Concepts Office
- **ECBC** – Edgewood Chemical Biological Center
- **IDA** – Institute for Defense Analyses
- **JPM-IS** – Joint Program Manager – Information Systems
- **JSLSCAD** – Joint Service Lightweight Stand-off Chemical Agent Detector
- **MSB (M&S/Battlespace)** – Modeling and Simulation / Battlespace
- **RDA** – Research Development and Acquisition
- **RDT&E** – Research, Development Testing and Evaluation
- **T&E** – Testing and Evaluation
- **S&T** – Science and Technology
- **UNM/NMSU** – University of New Mexico / New Mexico State University
- **VP** – Virtual Prototypes; Virtual Prototyping

Flatland Visualization of A Decision Support Tool Architecture

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The Problem

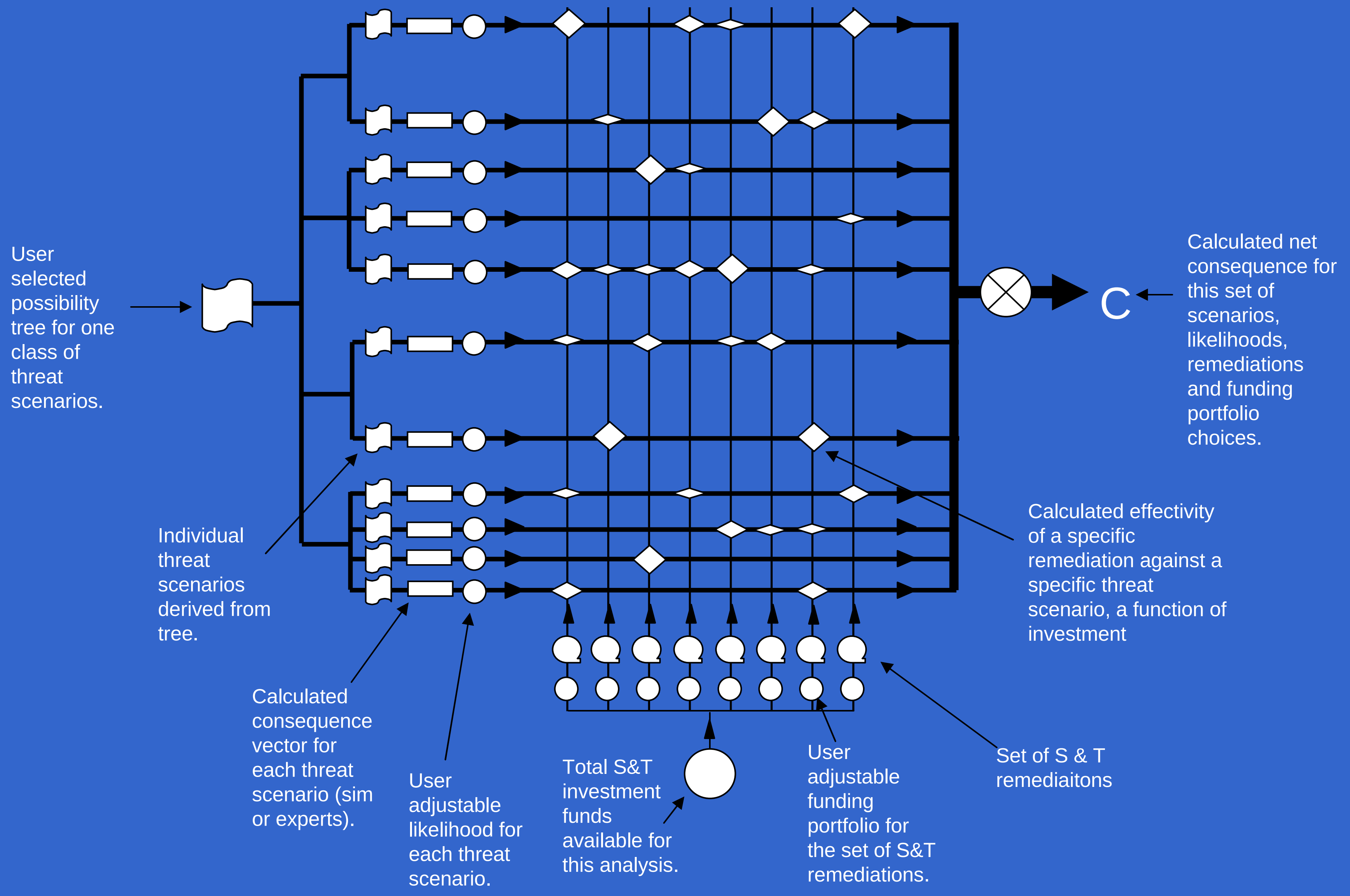
Allocation of Science & Technology (S&T) research funding to maximally reduce the threat and consequences of CB attacks on critical assets is complex and very hard to optimize globally.

Design Goals

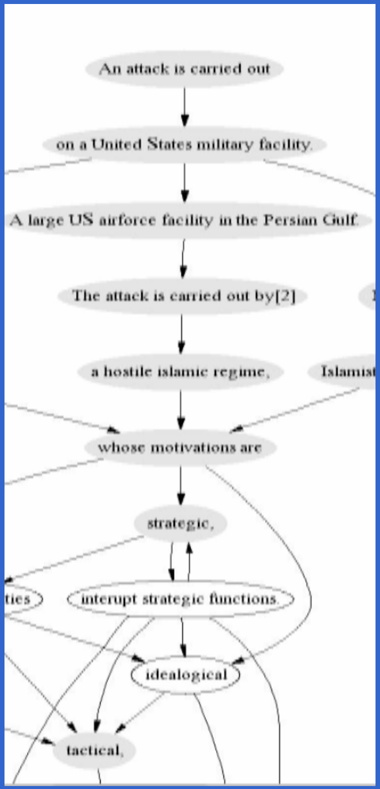
- Develop an analytic and algorithmic framework for threat consequence minimization.
- Create a feasible system architecture to evaluate modeling, analysis approaches, and user interactions within this framework.
- Enhance decision process transparency.

Initial Architecture

No Temporal Dynamics



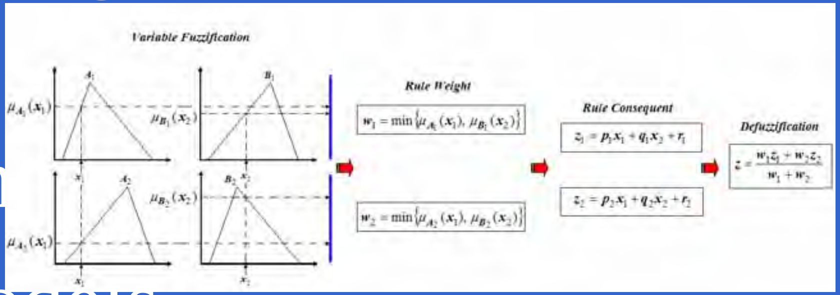
Specification of Scenarios



- Possibility Trees
- Spanning sets of scenarios
- Vectors of consequences per scenario
- Possible continuous scenario space
- Possible continuous consequence space

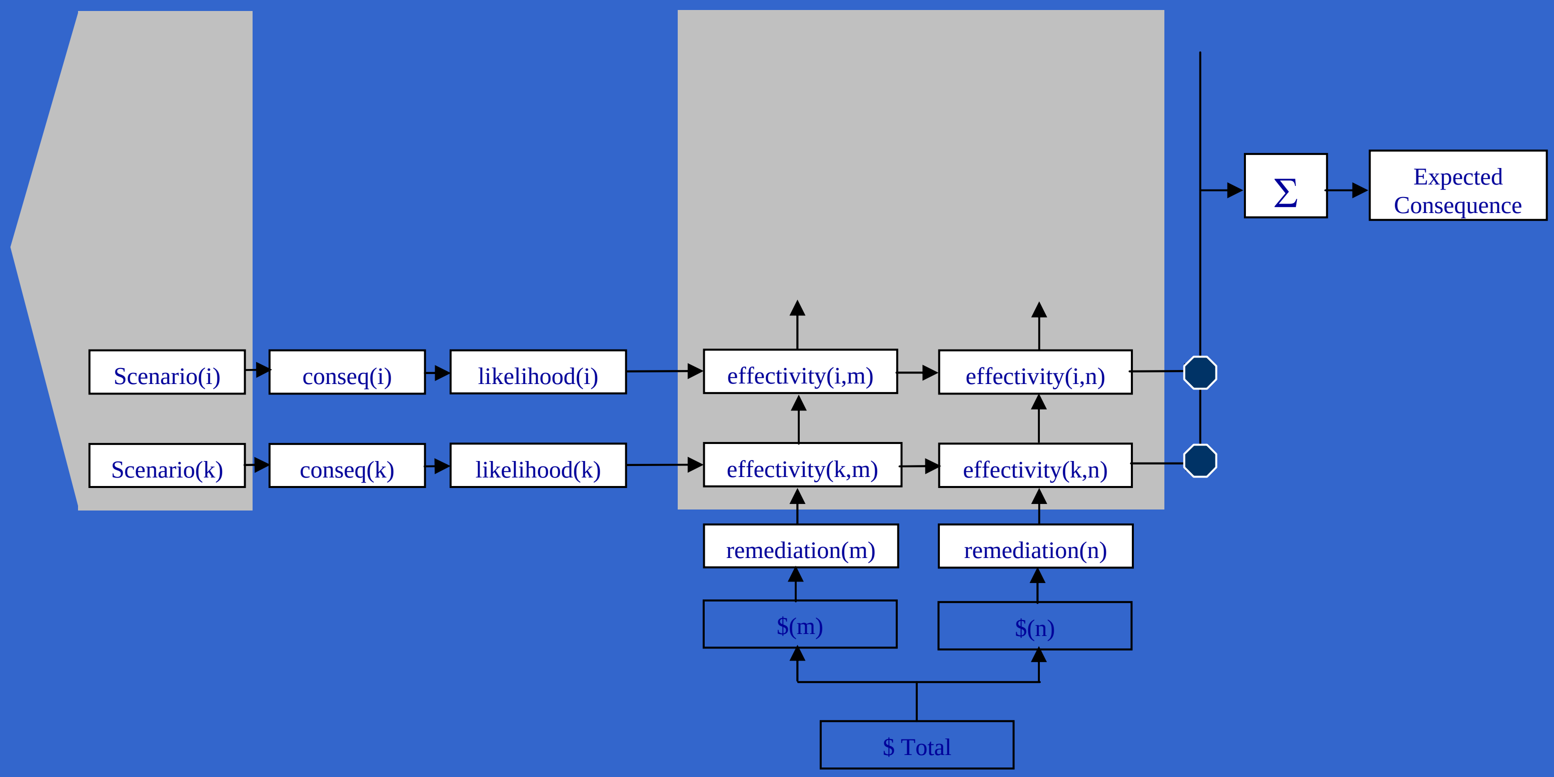
Creating Models of Consequences, Costs, and Effectiveness

- Relate remediation funding level to its effectiveness against a given scenario's consequences.
- Scientific Simulation
- Machine learning models
- Knowledge based systems



Details of Architecture

Consequence Flow Model



Mockup Mathematical Model

Assumes only one type of consequence per scenario.

$$\text{Expected Conseq} = \alpha \sum_{k=1}^{\text{NumScenarios}} \text{conseq}(k) * \text{likelihood}(k) * \prod_{m=1}^{\text{NumRemediations}} (1\text{-effectivity}(k,m))$$

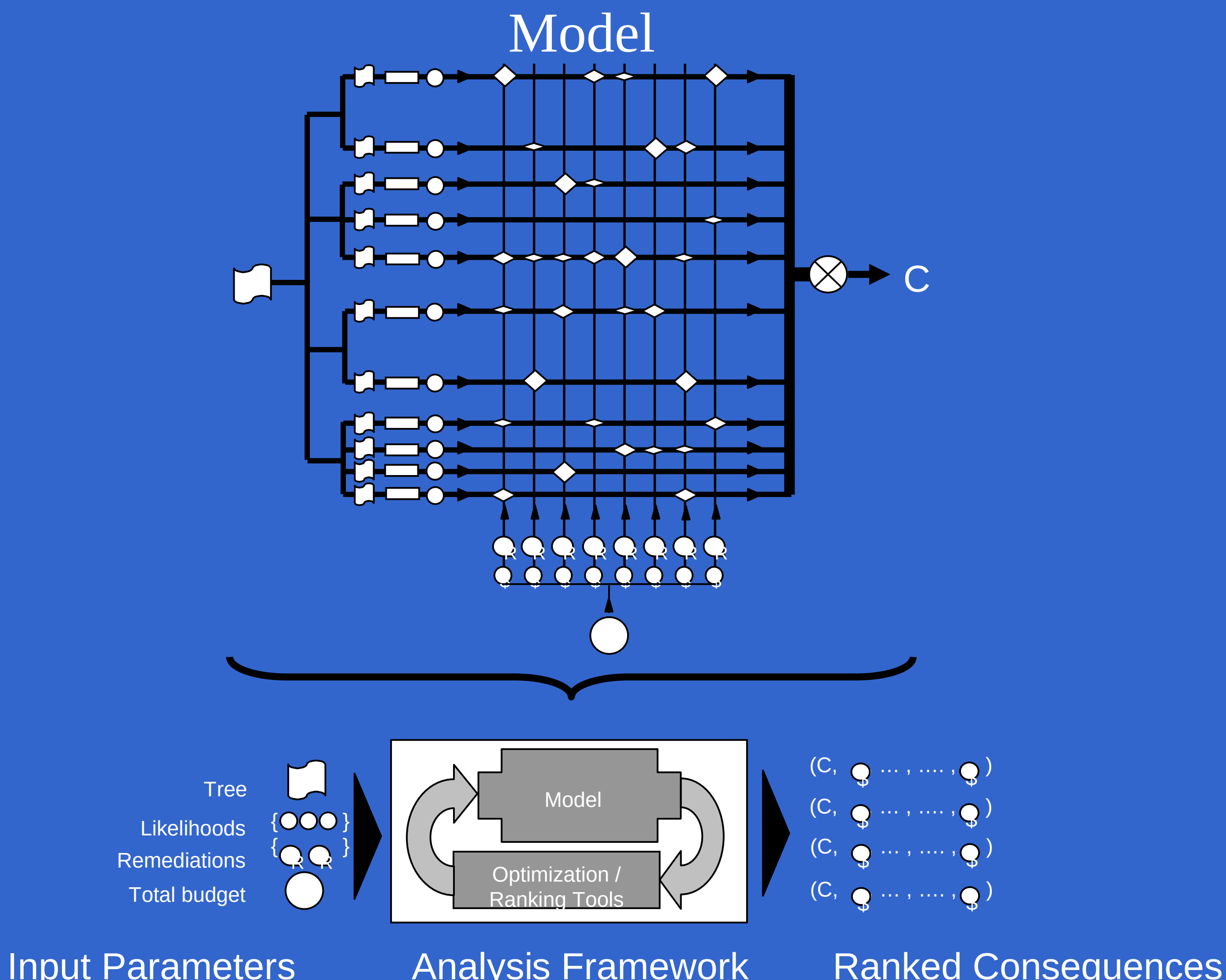
Where:
* α is a normalization constant,
* conseq(k) is a real scalar,
* likelihood(k) is a probability (sums to 1),
* $(m) is a real (sums to $ Total = 1),
* effectivity(k,m) = β(k,m) * F($(m)),
* β(k,m) = rand(0,1).

User Adjustables:

a) {likelihood(k), k=1, NumScenarios}

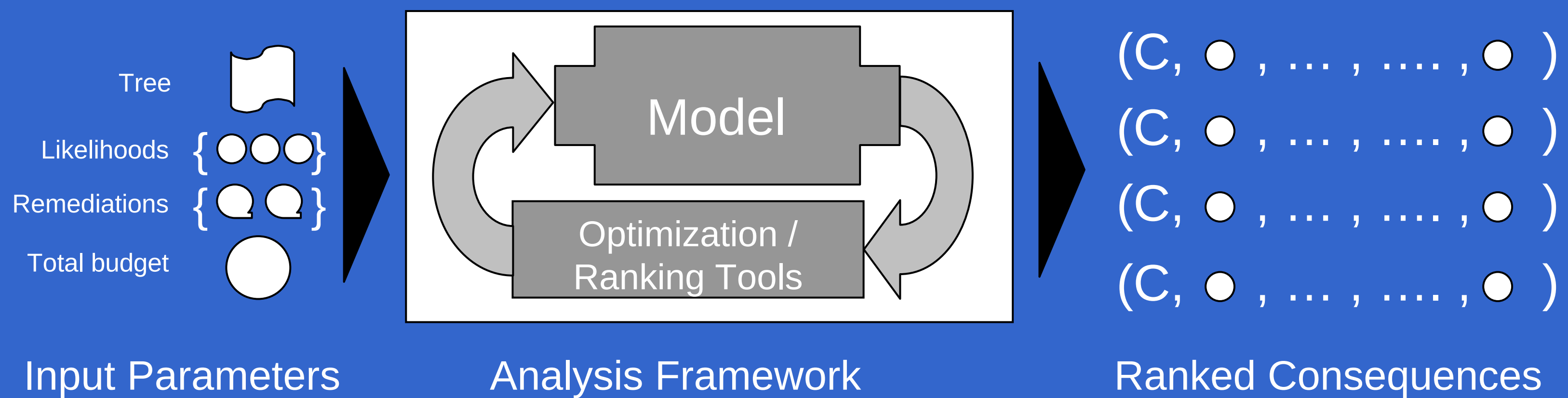
b) {$(m), m=1, NumRemediations}

Optimization Loop



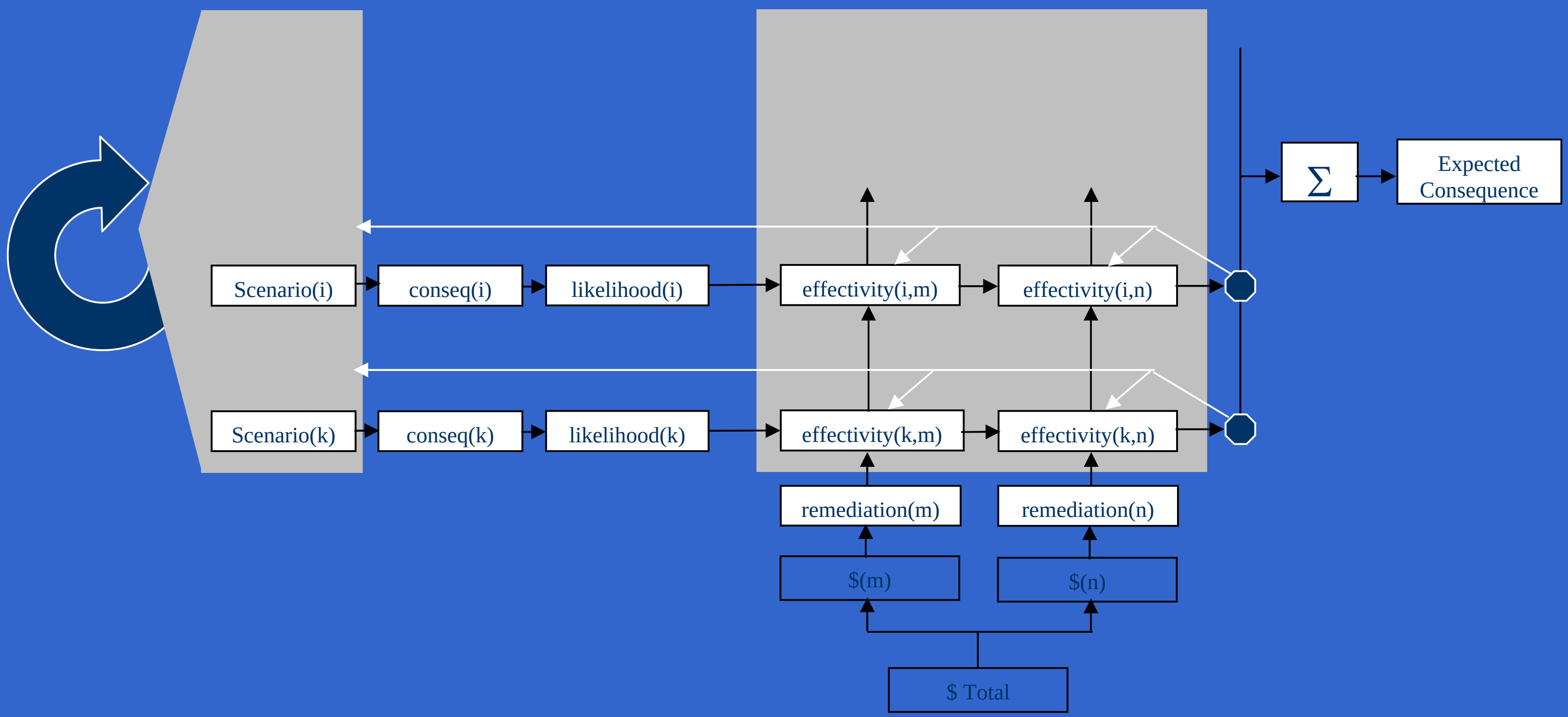
Optimization

Allocation of funds to minimize expected consequences



Mockup: $\$_n(k+1) = \$_n(k)$ - eta * gradient(Expected Consequences)

Temporal Dynamics



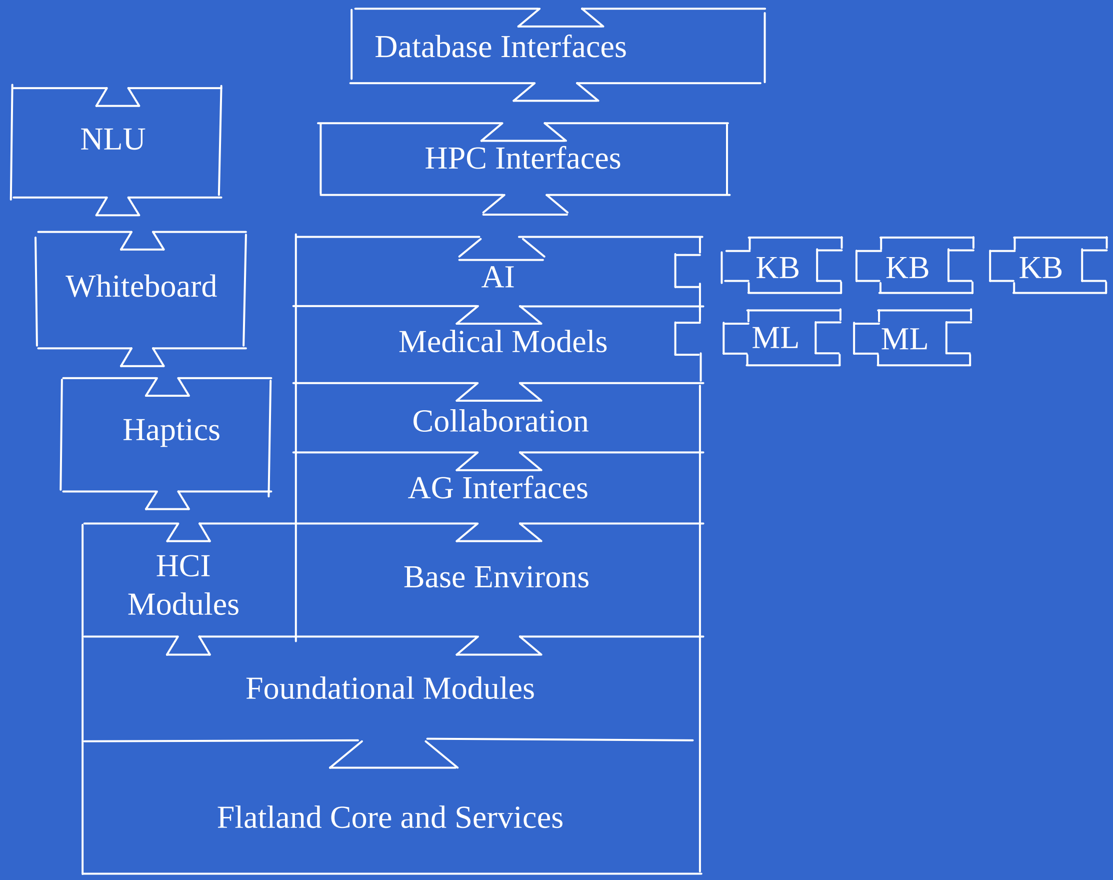
The visualization team

- Shan Xia - UNM, ECE
- Victor Vegara- UNM, ECE
- Panaiotis- UNM, ECE & Music
- Steve Smith- LANL
- Thomas Caudell- UNM, ECE & CS

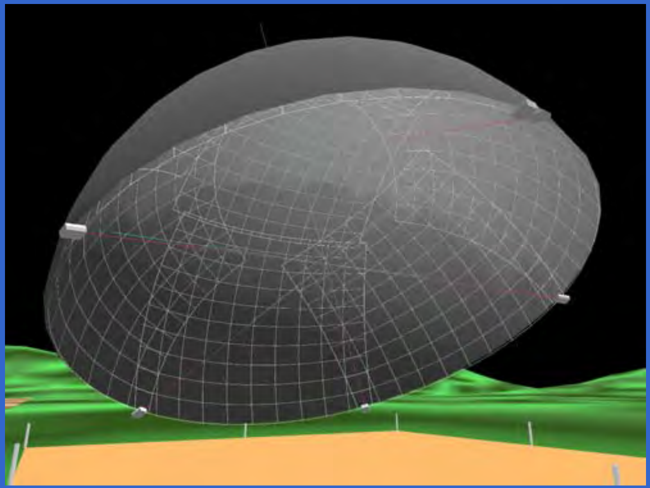
Features of visualization

- Goal: transparency into computational model and decision process.
- Consequence-flow metaphor
- Real-time user adjustable parameters
- User viewpoint control to manage complexity
- Drill-down for more details
- Animation of calculations and optimization
- Complementary sound representation of system states and dynamics
- Implemented in Flatland.

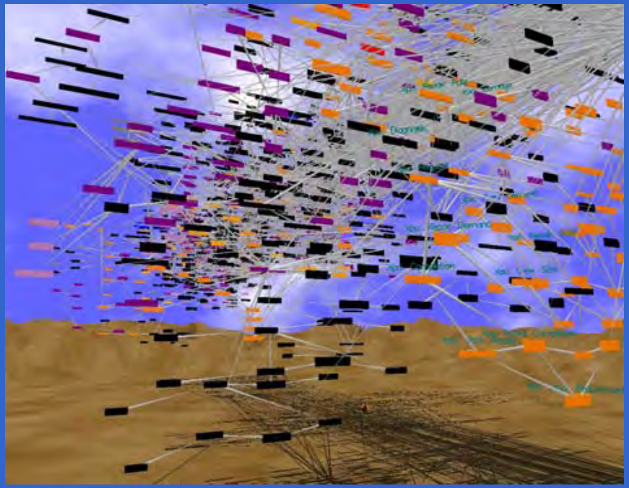
Flatland: modular applications

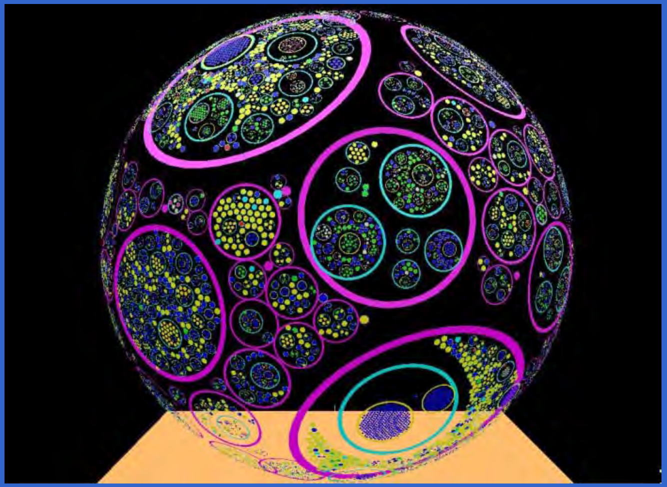


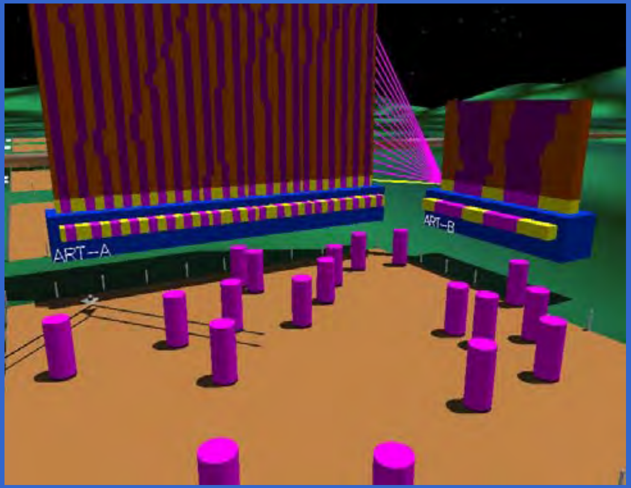
Displays: visual and sound

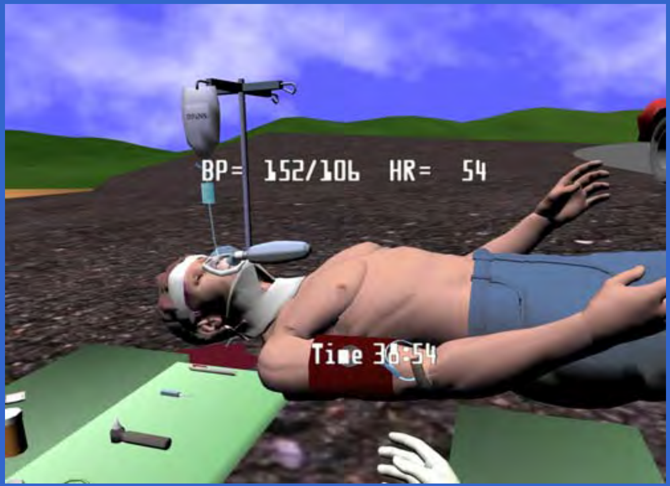


Widely applied

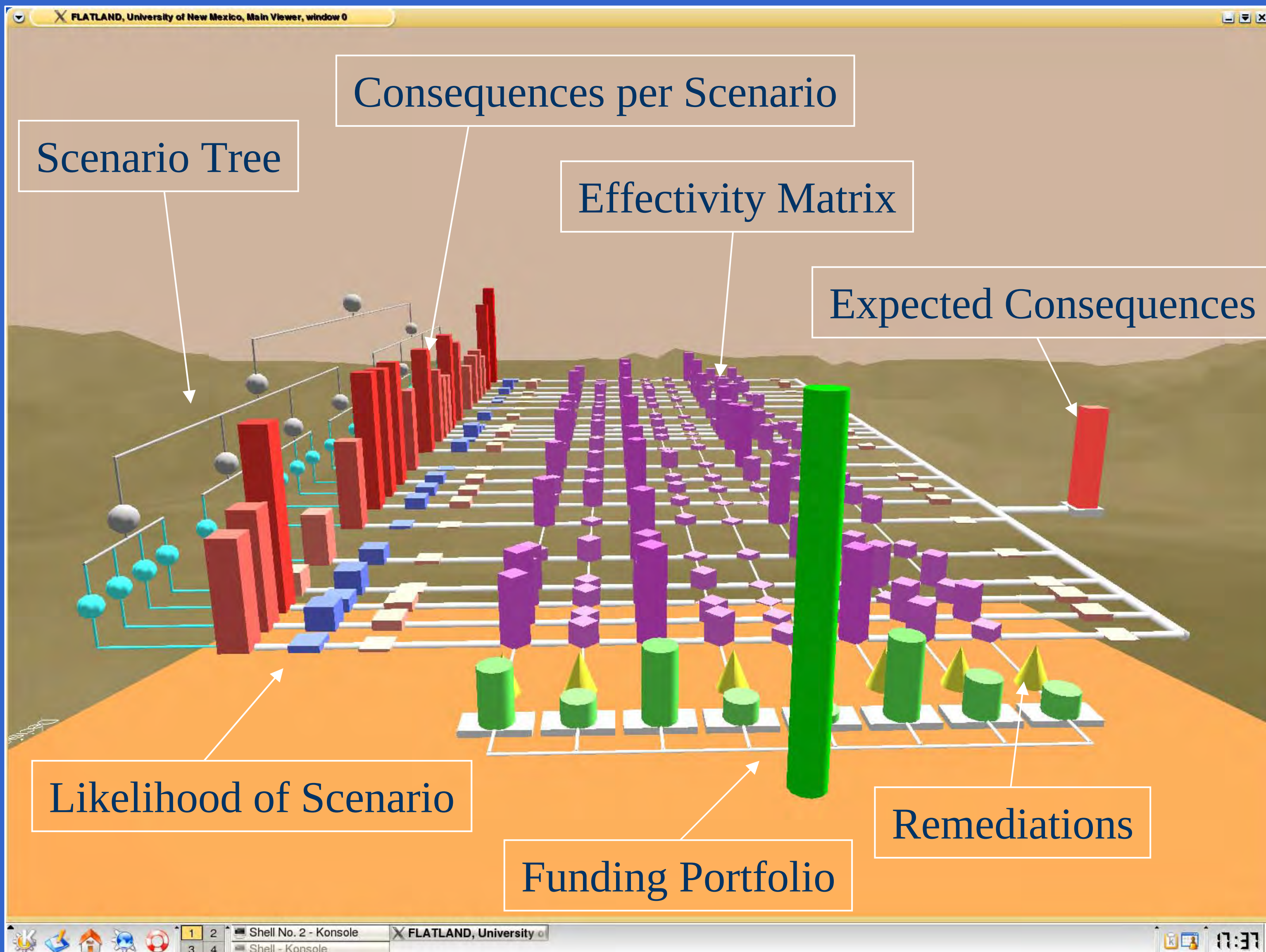




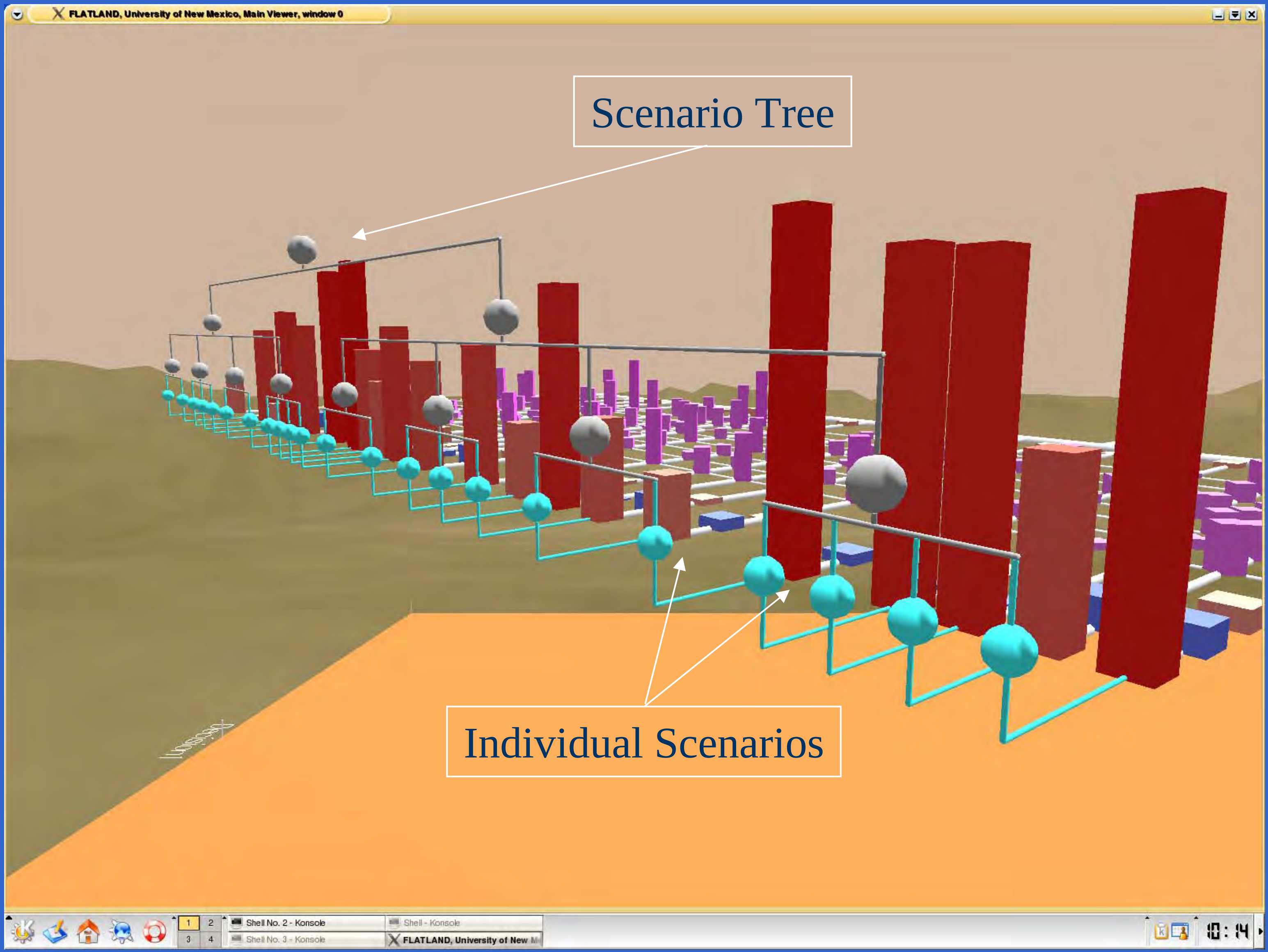




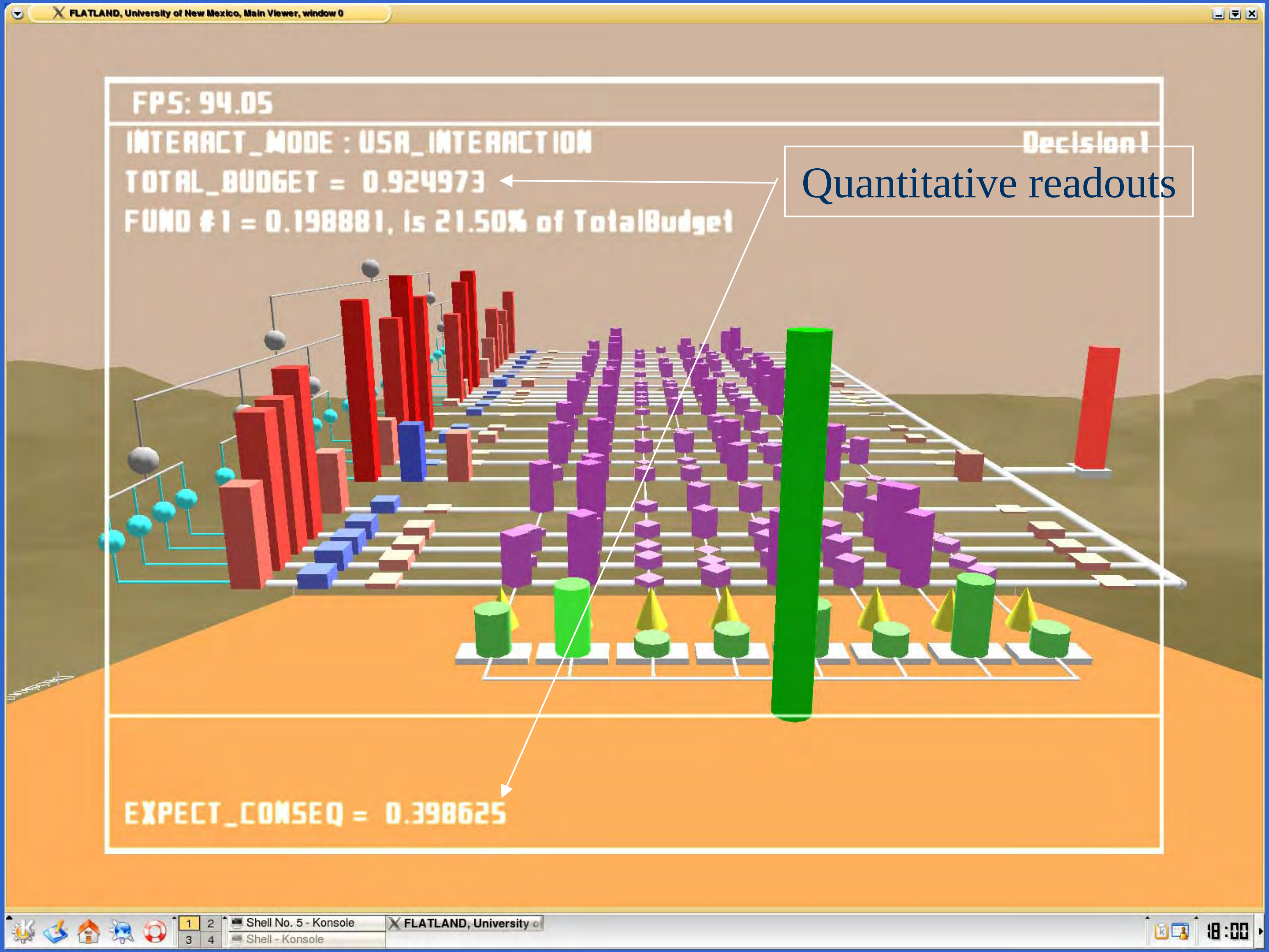
Visualization of Mockup System



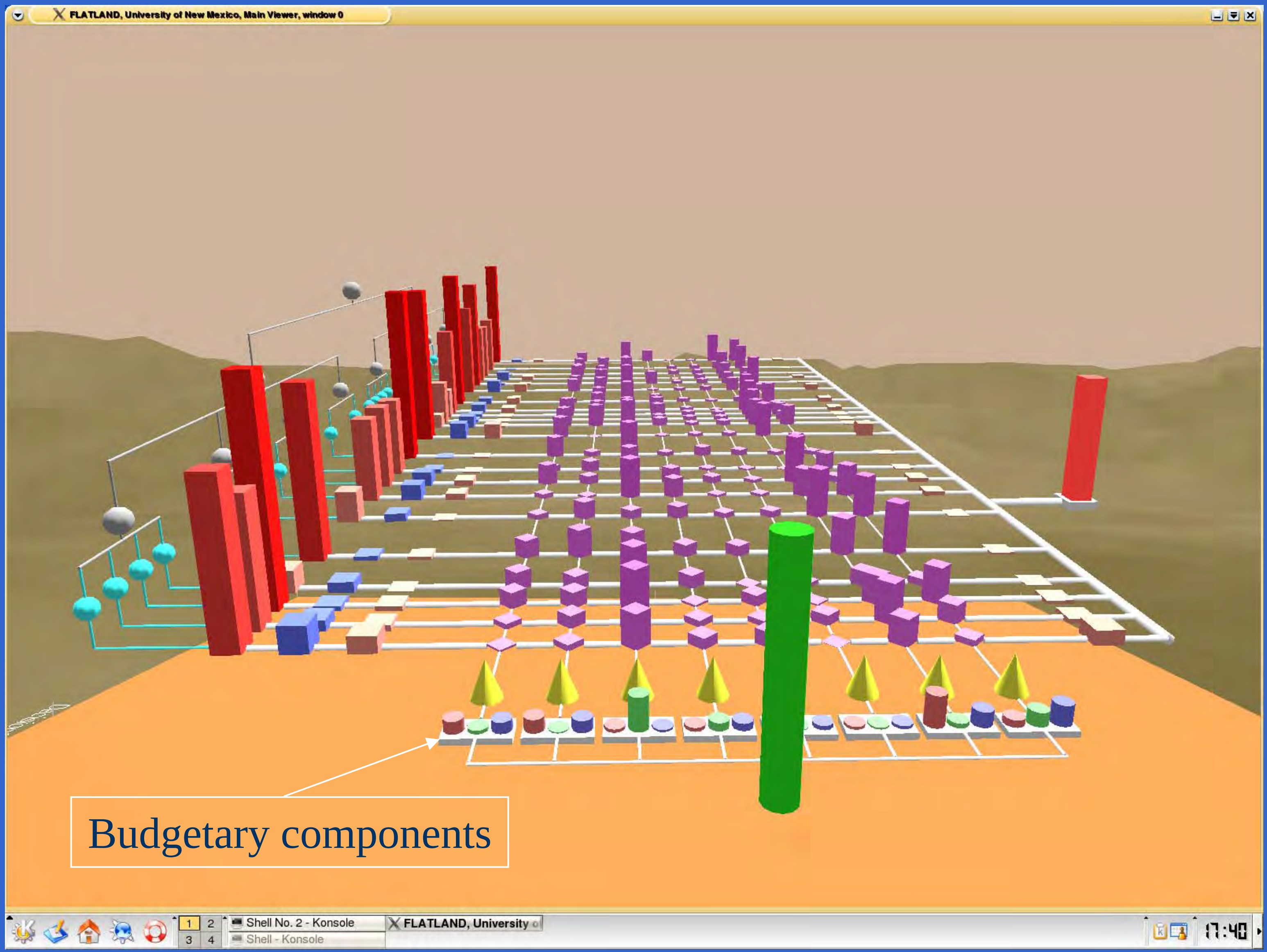
Visualization of Mockup System



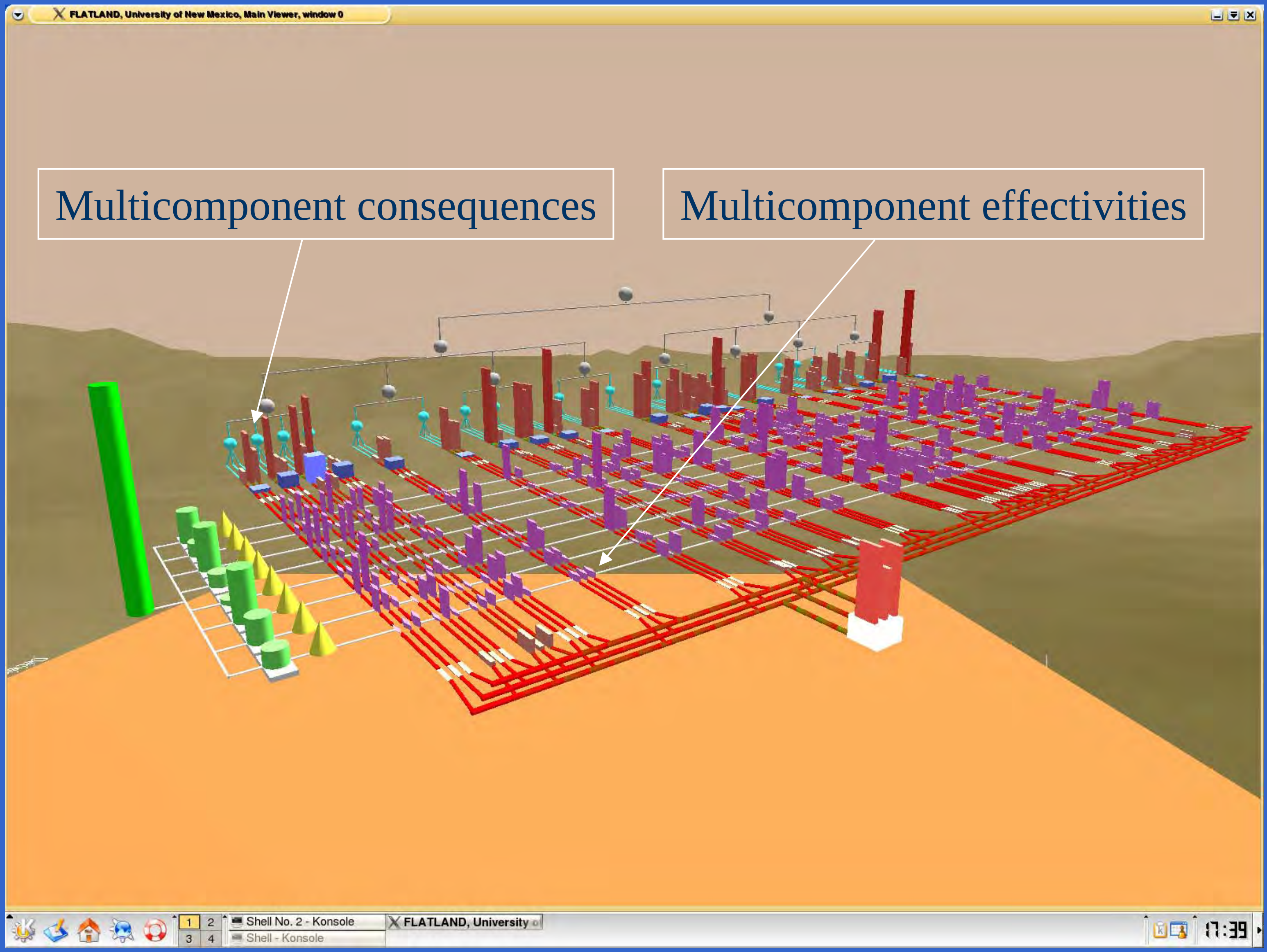
Visualization of Mockup System



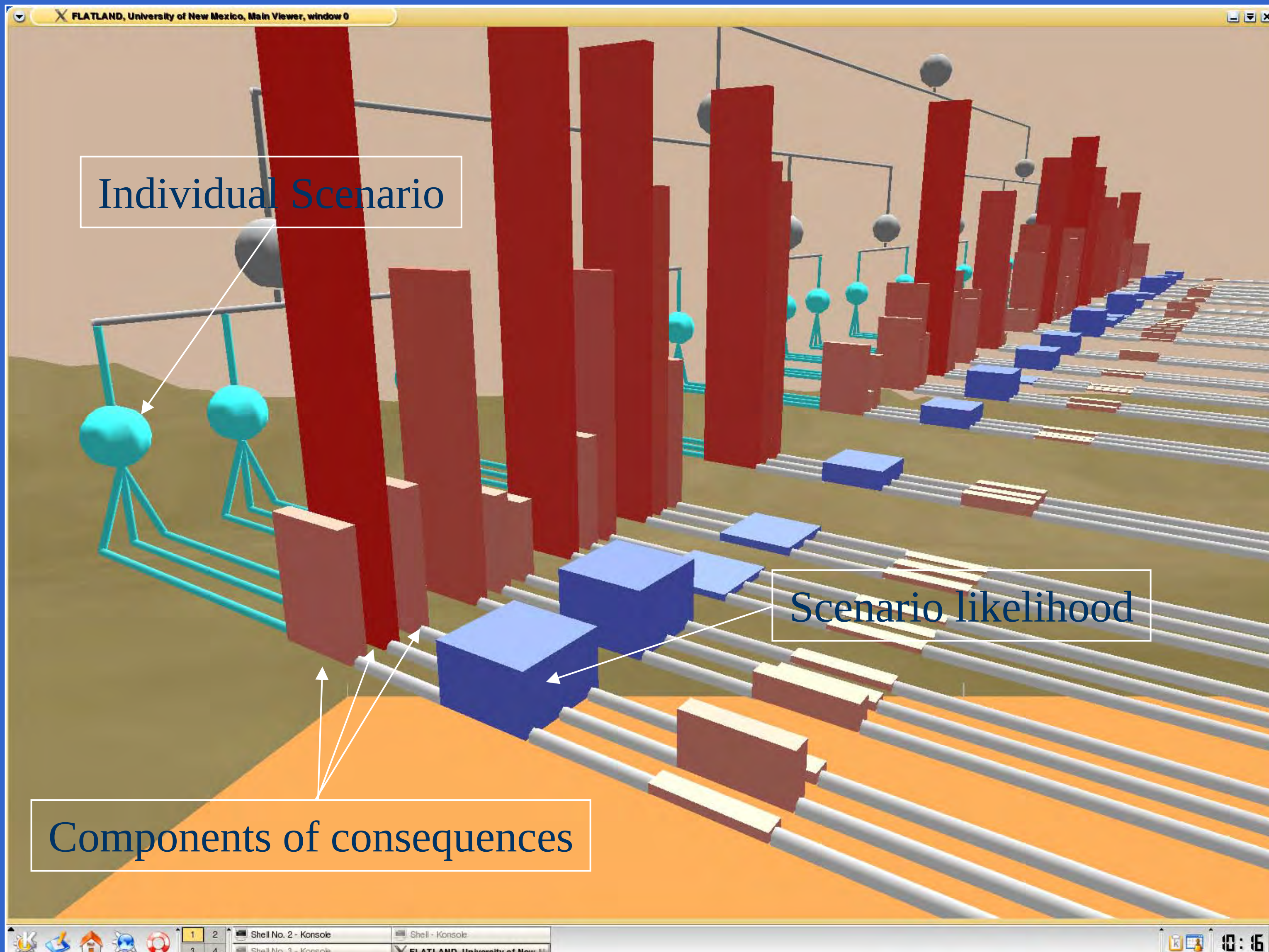
Visualization of Mockup System



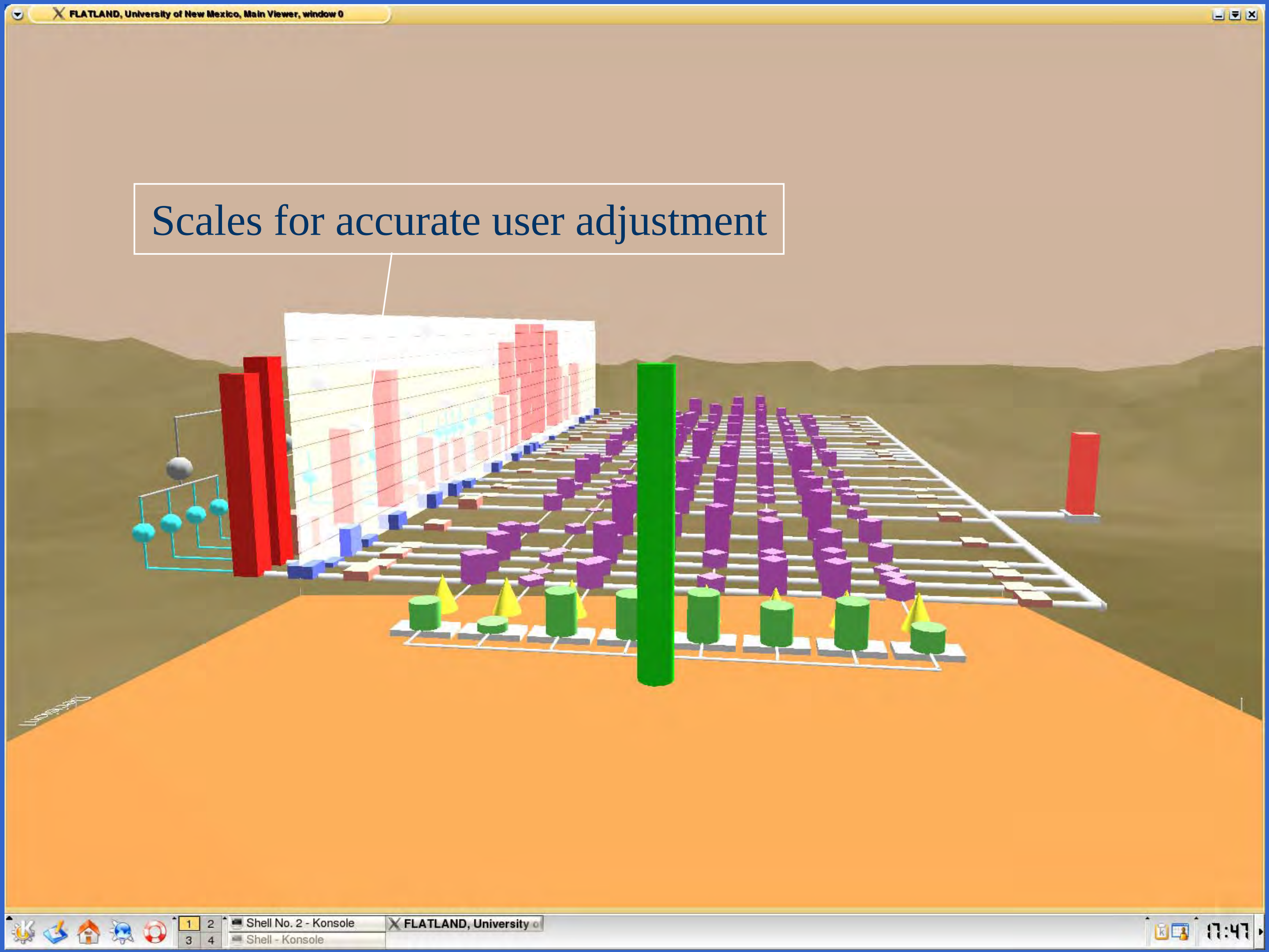
Visualization of Mockup System



Visualization of Mockup System



Visualization of Mockup System



Future advancements

- Integration with models and optimization,
- Integration with scenarios,
- Scalable scenario & remediation representations,
- Effectivity model representations,
- Quantitative measures of performance.

Invitation to demonstration
at the
University of New Mexico
Visualization Laboratory
Center for High Performance Computing

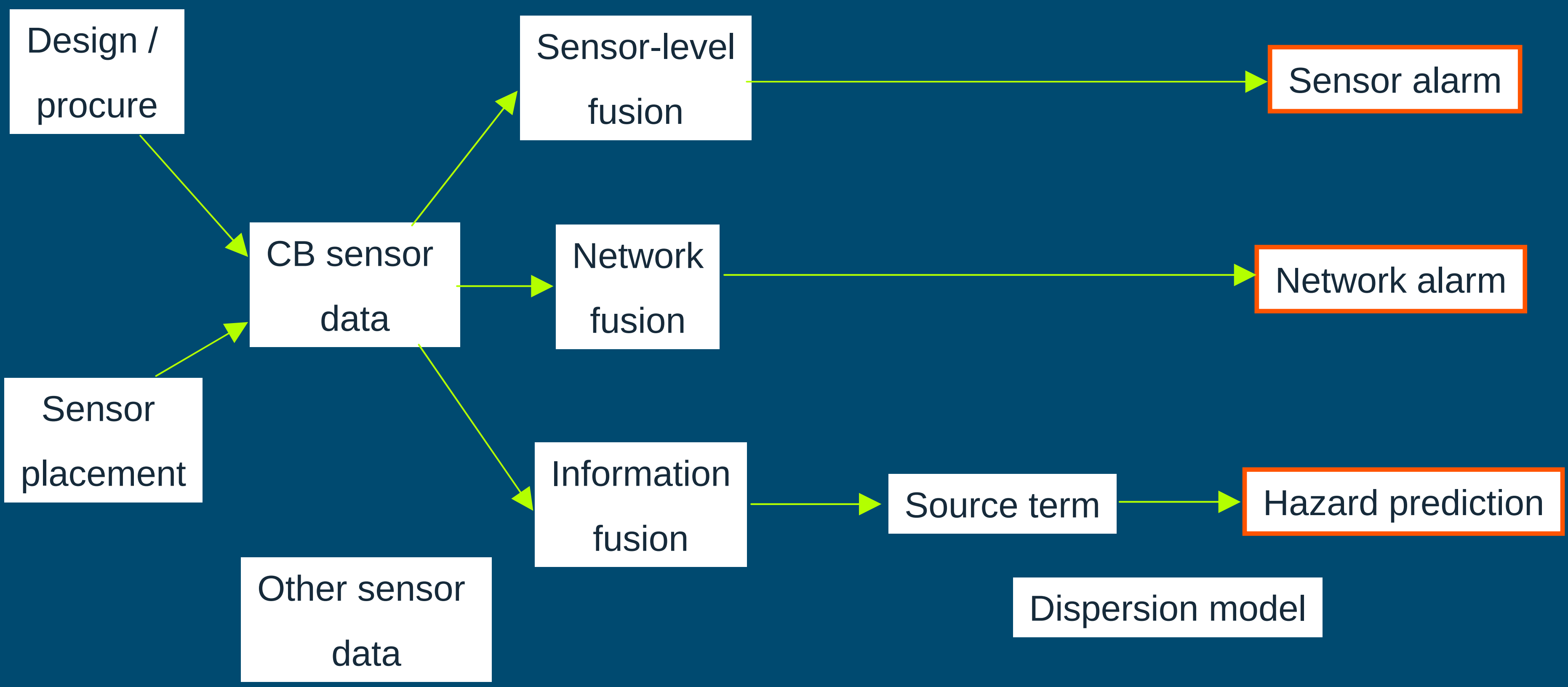
\- Thursday -

Contact: tpc@ece.unm.edu

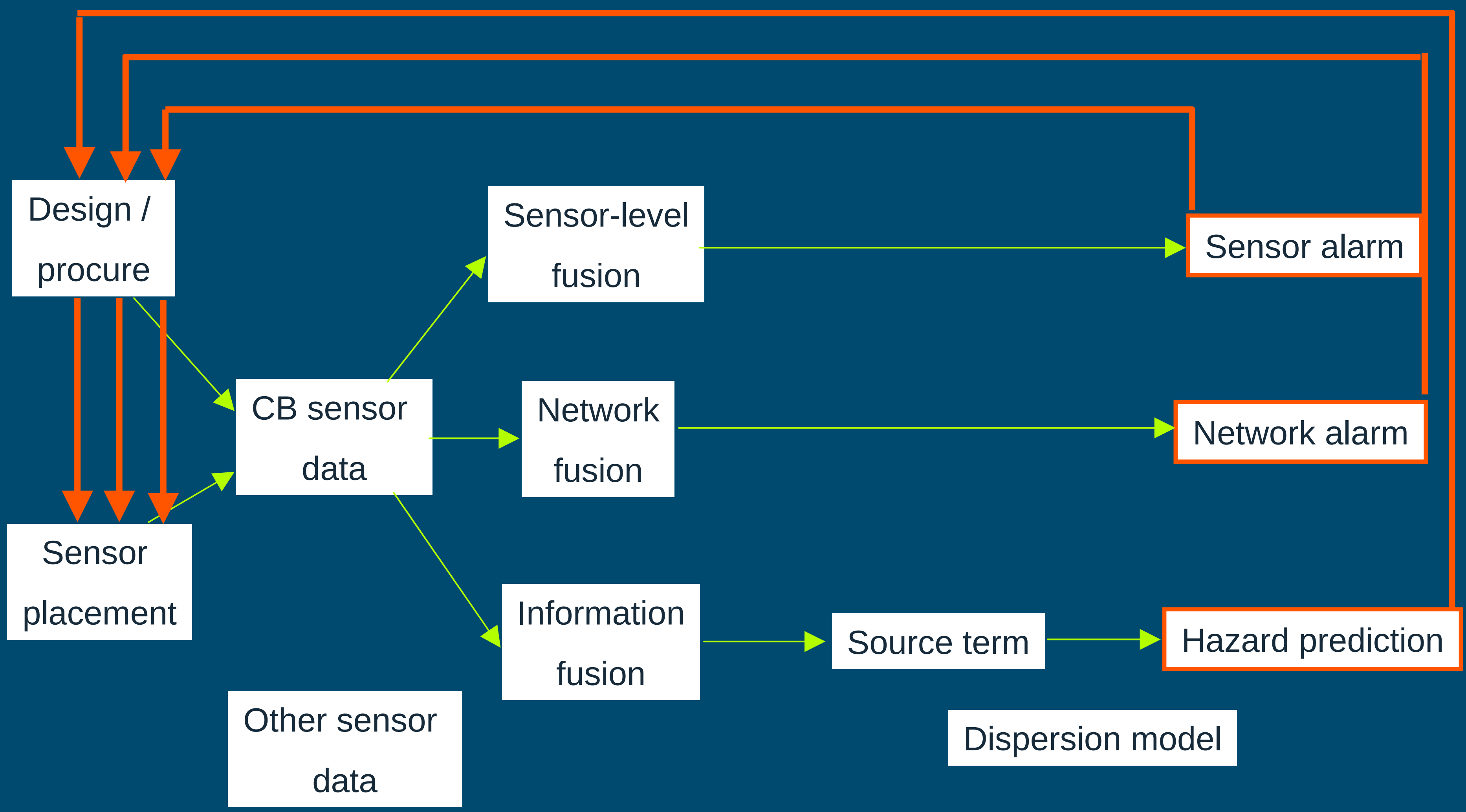
Fusion of Sensor and Model Data

Deb Fish, Oliver Lanning and Paul Thomas

The big picture...

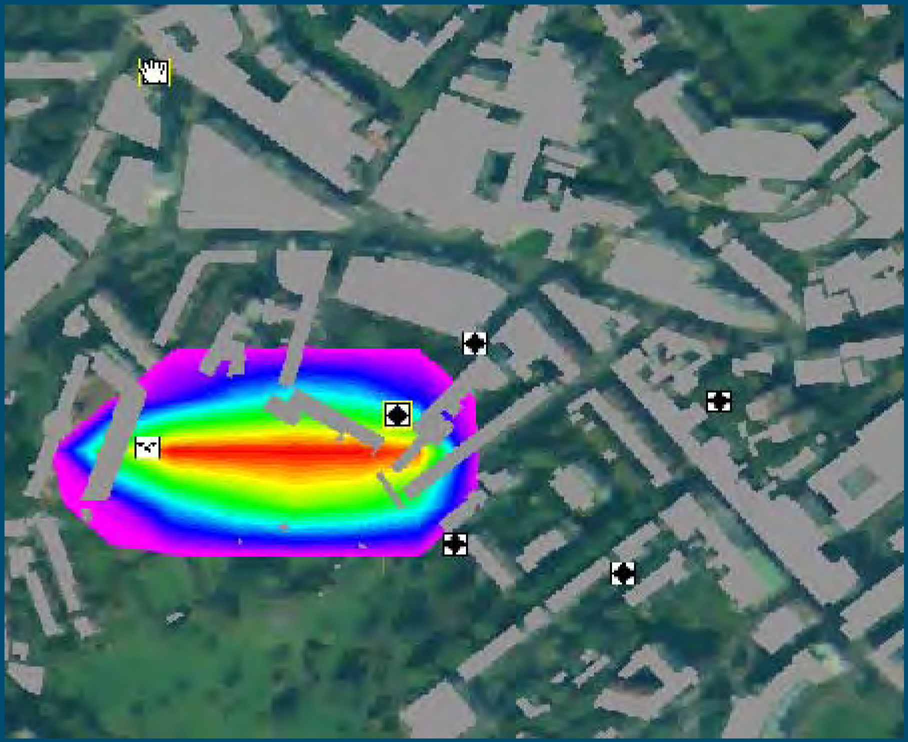


The big picture...



1) Sensor placement

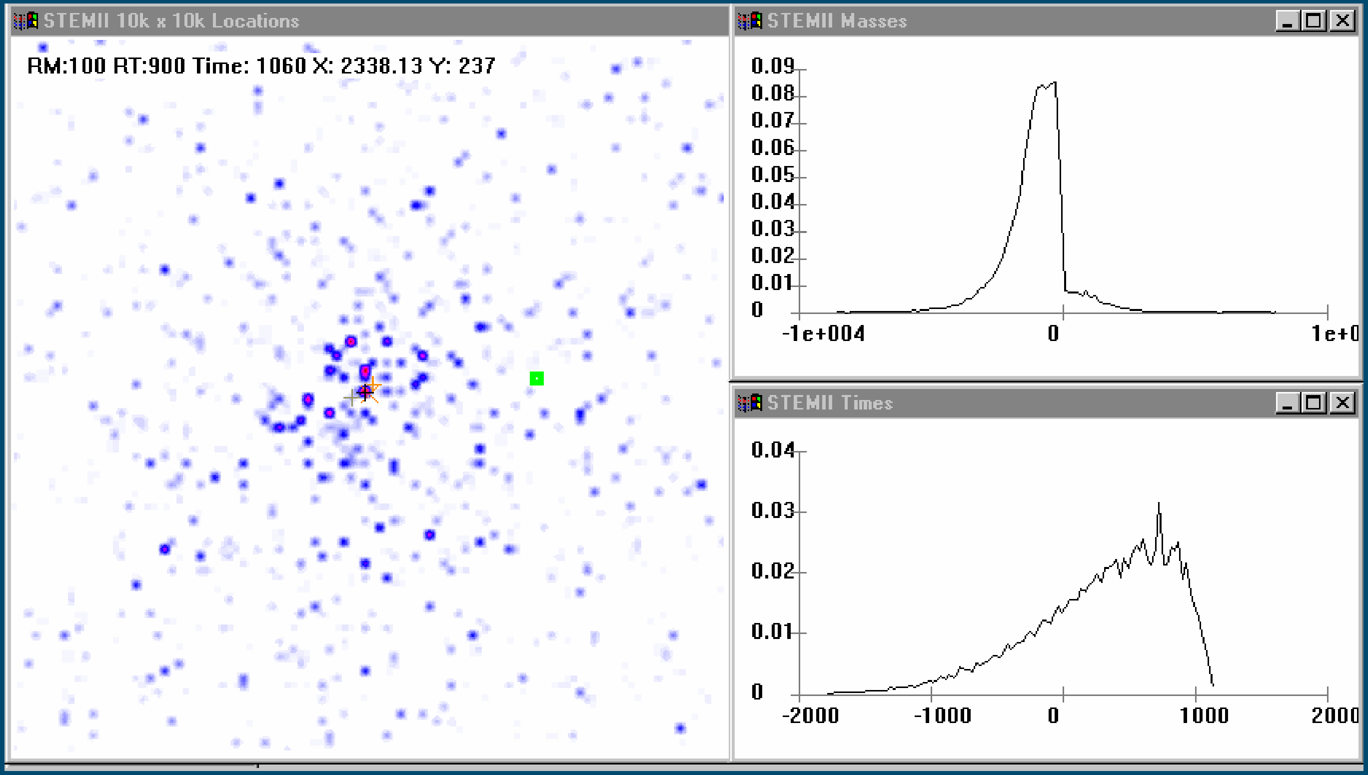
- 1) Place sensors to maximise probability of any sensor detecting a release
- 2) Place sensors to maximise detection capability of the sensor network
- 3) Place sensors for optimal hazard prediction
- 4) Target UAVs and other mobile sensors...



2) Sensor procurement

- 1) Design individual sensors based on key metrics
  - sensitivity
  - probability of detection
  - false positive rate
  - response time
- 2) Procure heterogeneous network of sensors to optimise key metrics at the *system level*, for the area to be protected
- 3) Design sensor network to optimise quality of hazard prediction

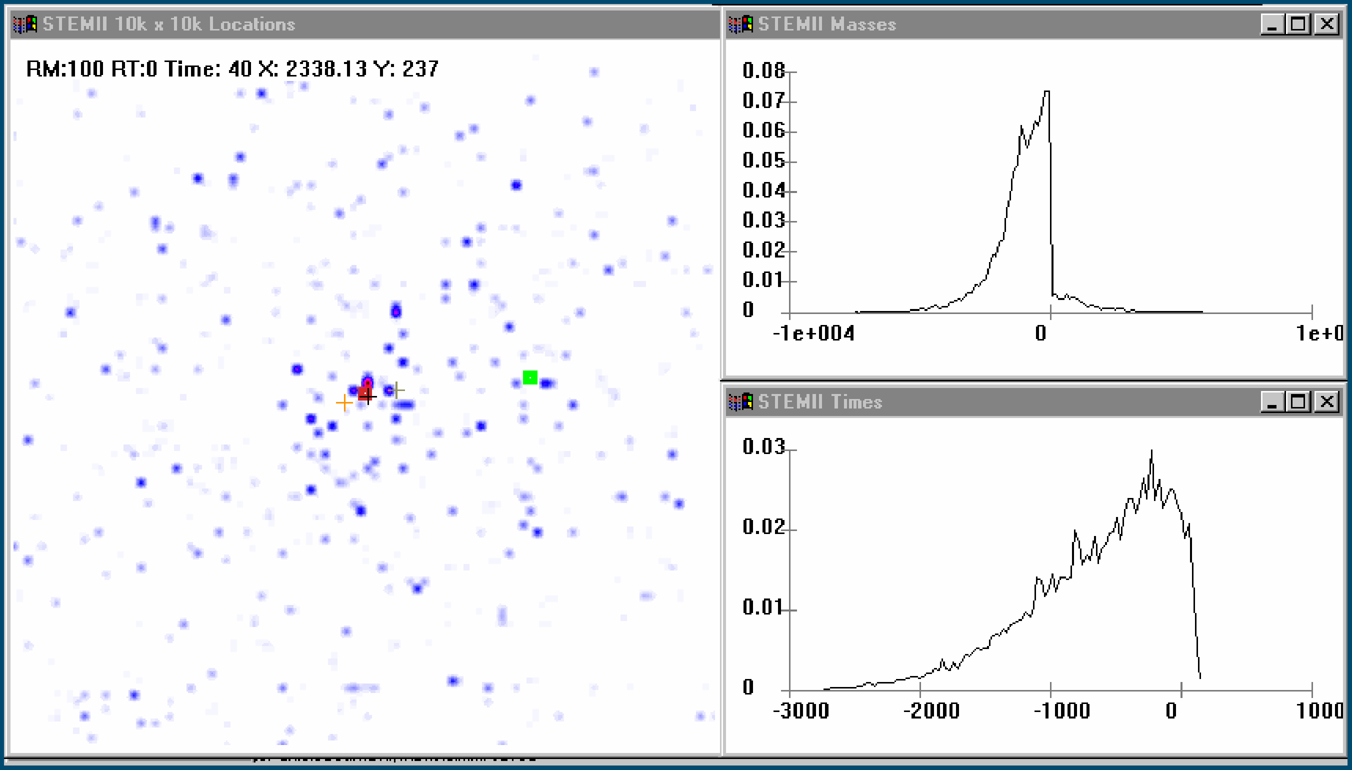
Optimal biosensor for identification - resonant mirror



31 October 2005

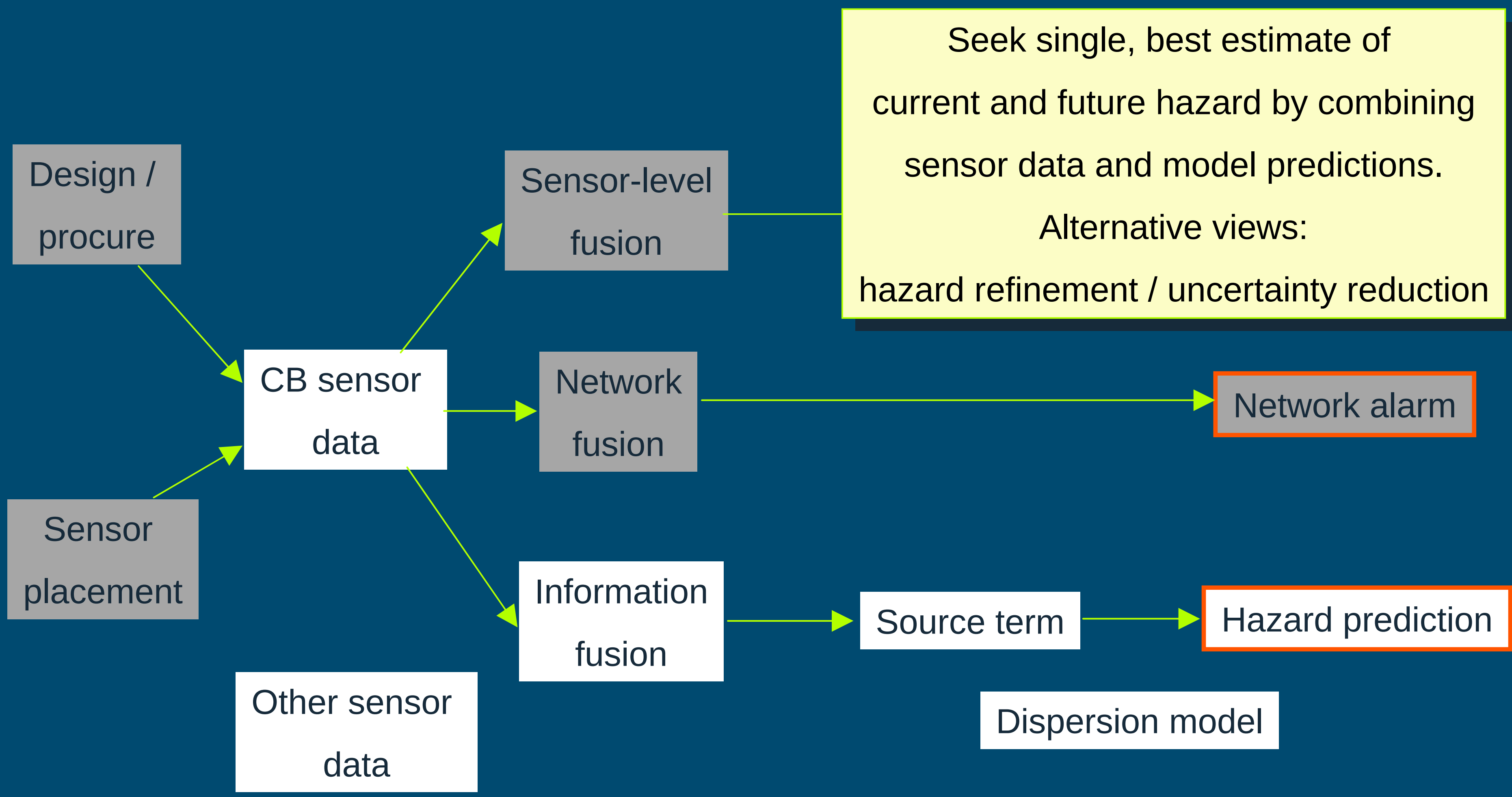
Dstl is part of the Ministry of Defence

Better biosensor for hazard prediction - particle counter?



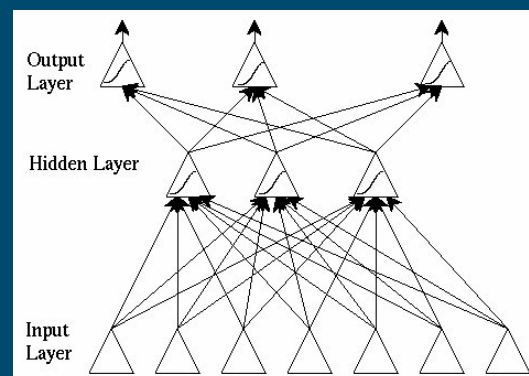
Impact of single sensor on source term estimation only - conclusions are limited!

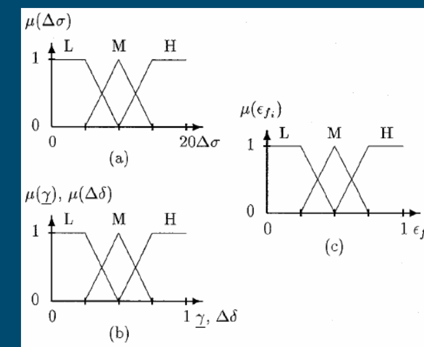
3) Fusion of sensor and model data

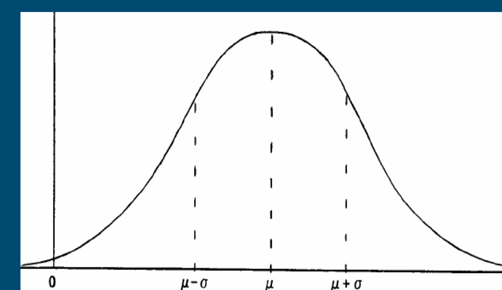


3a) Literature Review

- Investigated wide variety of possible methods
  - Bayes theory
  - Kalman Filter
  - Fuzzy Logic
  - Genetic Algorithms
  - Neural Networks
  - Variational Assimilation
  - Optimal Interpolation







- Chosen short list of suitable techniques for implementation into a synthetic environment

Bayesian fusion

$$p(H \mid D) = \frac{p(D \mid H)\, p(H)}{p(D)}$$

- ✓ Mathematically rigorous
  - ✓ incorporates uncertainty
- ✓ Simple in concept
- ✓ Incorporates prior knowledge
- ✓ Can be extended to incorporate any information
  - ✓ observer range and bearing

- × No absolute probabilities
- × Difficult to implement (complex integrals)
- × Computationally demanding

Kalman filter

$$\mathbf{x} = \mathbf{x}^{\mathrm{b}} + \mathbf{K}\left(\mathbf{y} - \mathbf{H}\mathbf{x}\right)$$

$$\mathbf{K} = \left(\mathbf{B}^{-1} + \mathbf{H}^{T}\mathbf{R}^{-1}\mathbf{H}\right)^{-1}\mathbf{H}^{T}\mathbf{R}^{-1}$$

- ✓ Sequential predictor-corrector data fusion method
  - ✓ incorporates uncertainty
- ✓ Provides prediction of the error covariances
- ✓ Incorporates prior knowledge

- × KF only for linear models
  - × Use extended or ensemble KF for non-linear models
- × Can be computationally demanding

Variational Data Assimilation

$$J(\mathbf{x}) = \frac{1}{2}\left(\mathbf{x}-\mathbf{x}^{\mathbf{b}}\right)^T \mathbf{B}^{-1}\left(\mathbf{x}-\mathbf{x}^{\mathbf{b}}\right) + \frac{1}{2}\sum_{i=1}^{N}\left(\mathbf{y}_i - \mathbf{H}\mathbf{x}_i\right)^T \mathbf{R}^{-1}\left(\mathbf{y}_i - \mathbf{H}\mathbf{x}_i\right)$$

- ✓ Variational method
  - ✓ Assimilates all sensor data simultaneously
- ✓ Determines optimal analysis by solving the cost function
  - ✓ Provides gradient of analysis

- × Can be very computationally demanding
- × Does not determine the analysis directly

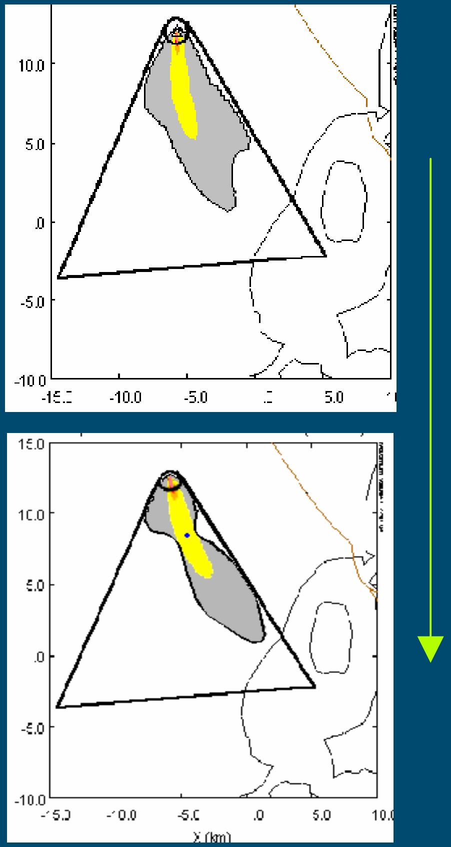
Overview of optimal techniques

	Use observations at the same time	Use a time sequence of observations
Sequential	Optimal Interpolation	Kalman Filter, Bayes
Variational	3DVAR	4DVAR

- Most interested in techniques that use a time sequence of observations
  - Assumption that observations occur at the same time introduces additional error
- Comparison of sequential and variational methods

3b) Uncertainty propagation

- Crucial to quantify uncertainty in model predictions, as well as sensor data
  - source magnitude, time and location (x,y,z)
  - number of sources
  - meteorology (in complex environments) and turbulence
  - effects (e.g. casualties)
  - is data representative?
- MOD-funded uncertainty project



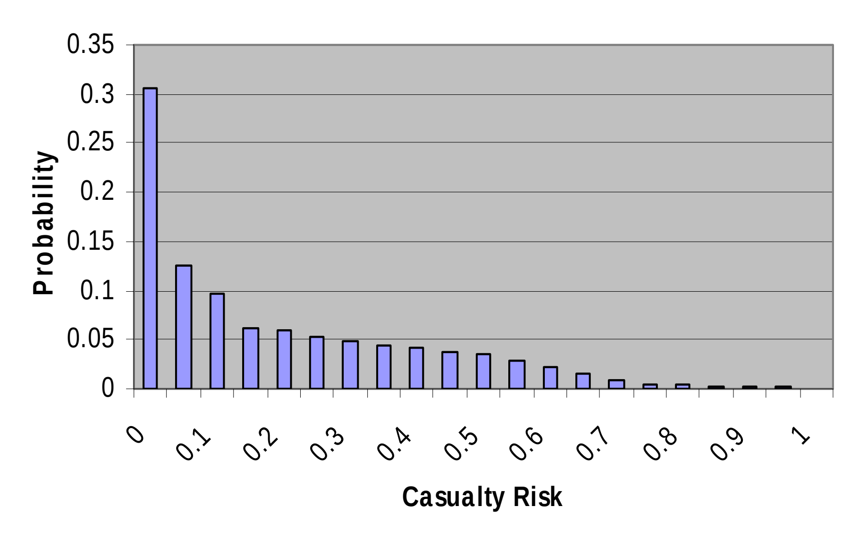
Reduce uncertainty, refine hazard

Uncertainty propagation

- Dstl have developed an uncertainty propagation framework:
  - takes probabilistic output from SCIPUFF / UDM
  - propagates uncertainty in casualties due to
    - respirator
    - breathing rate
    - toxicology
    - medical counter measures

Course of Action	Without IPE	With IPE	Different Location
Casualty Risk	100%	0%	0%

Uncertainty propagation

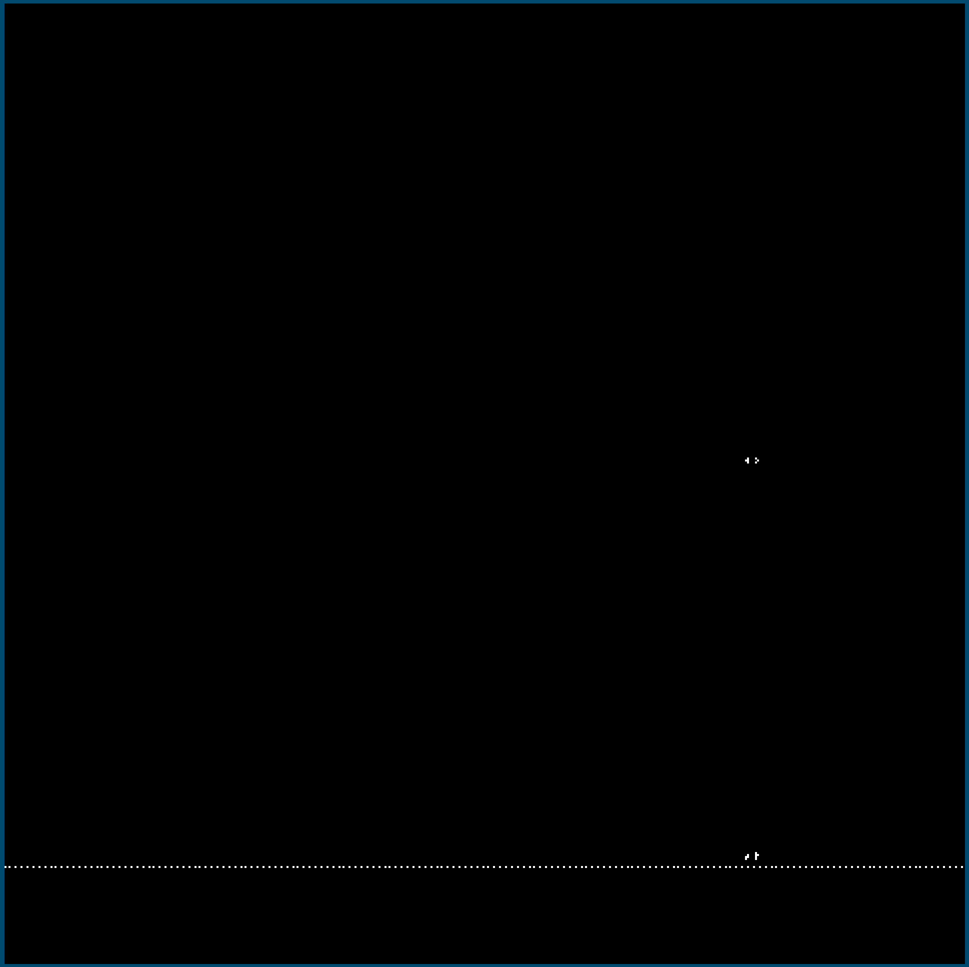


Course of Action	Without IPE	With IPE	Different Location
Casualty Risk	100%	0%	0%
Confidence Interval	90-100%	0-55%	0%

- Dstl have developed an uncertainty propagation framework:
  - takes probabilistic output from SCIPUFF / UDM
  - propagates uncertainty in casualties due to
    - respirator
    - breathing rate
    - toxicology
    - medical counter measures

3c) Sensitivity study

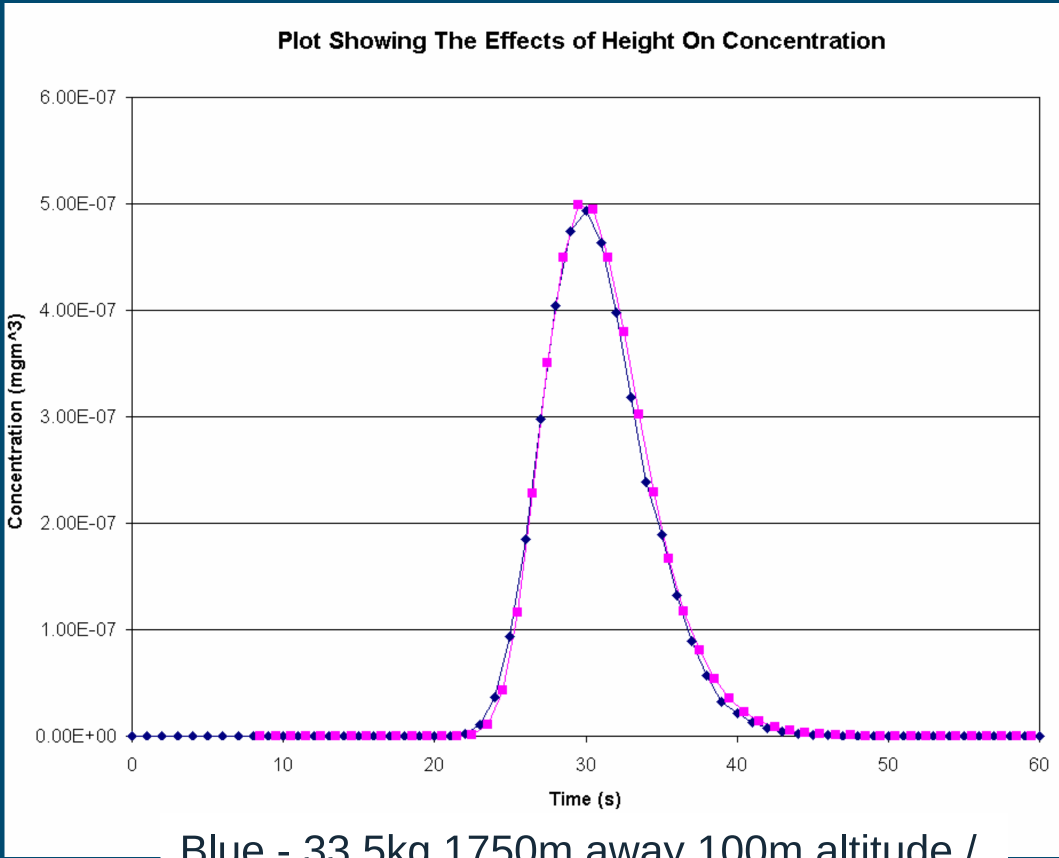
- Vary each input parameter in turn
  - source m,x,y,z,t
  - meteorology
  - turbulence
- Use synthetic environment to determine effect on output from range of possible sensors
  - CB sensors
  - meteorological sensors



3c) Sensitivity study

Identify inputs that have

- little effect on sensor output
  - neglect $\Rightarrow$ simplify problem
- correlations with other inputs
  - retrieve dominant input
  - use knowledge of correlations to understand / estimate uncertainty in hazard prediction
- large effect on sensor output
  - apply short-listed techniques to retrieve these inputs

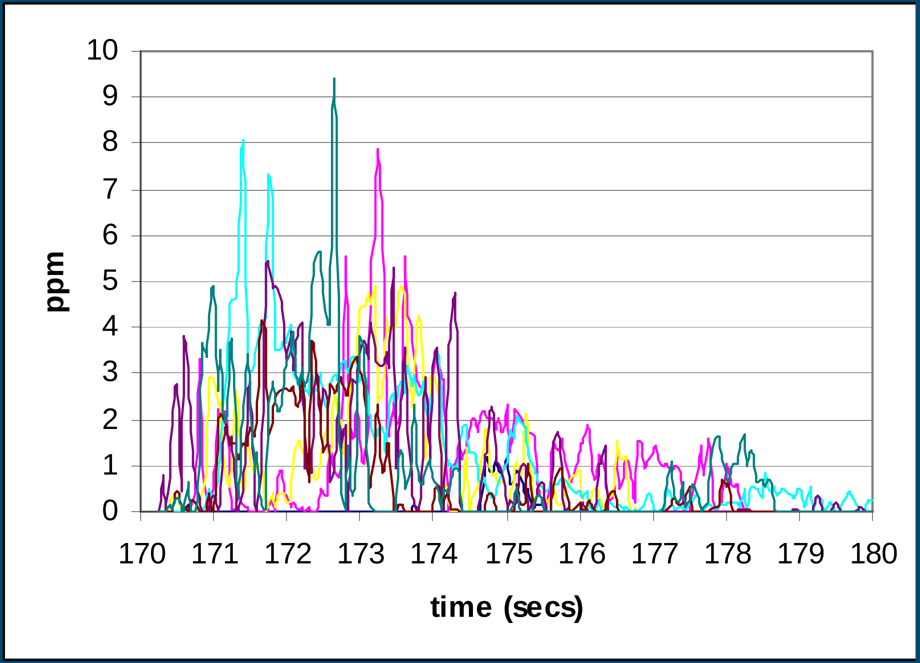


Blue - 33.5kg 1750m away 100m altitude /

Pink - 6 kg 1000m away 10m altitude

3d) Implementation in synthetic environment

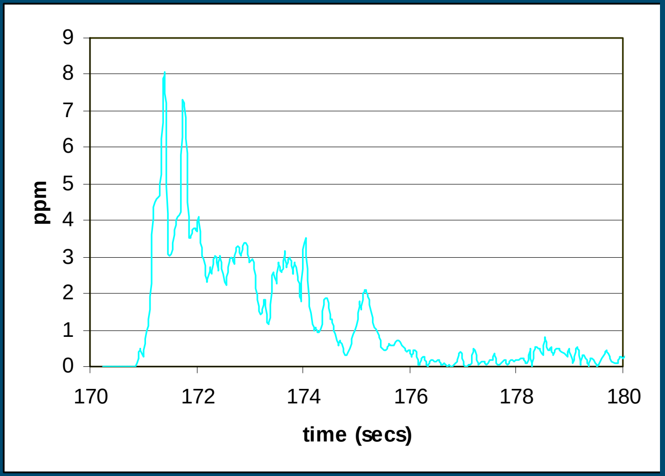
- It is essential to test the short-listed techniques in a realistic synthetic environment
  - meteorological forecasts subject to significant error
    - 30° error common
  - experimental concentration profiles show strong effects of turbulence
  - no sensor is perfect



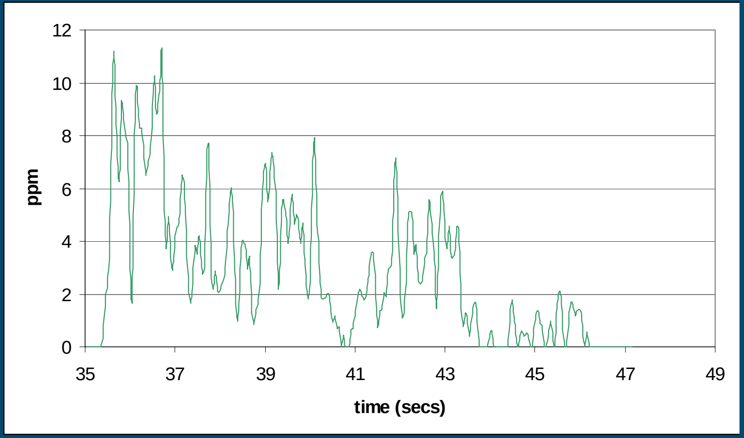
Measured effects of turbulence

3d) Implementation in synthetic environment

- It is essential to test the short-listed techniques in a realistic synthetic environment
  - meteorological forecasts subject to significant error
    - 30° error common
  - experimental concentration profiles show strong effects of turbulence
  - no sensor is perfect



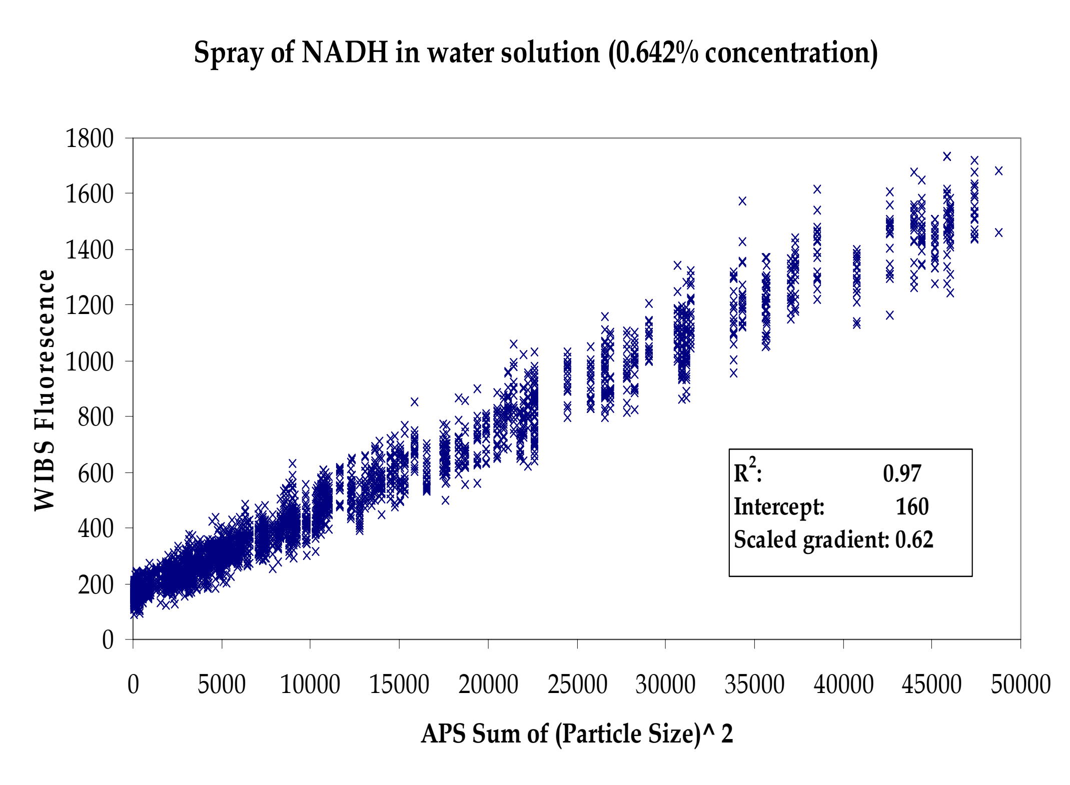
Data



Model

Synthetic environment

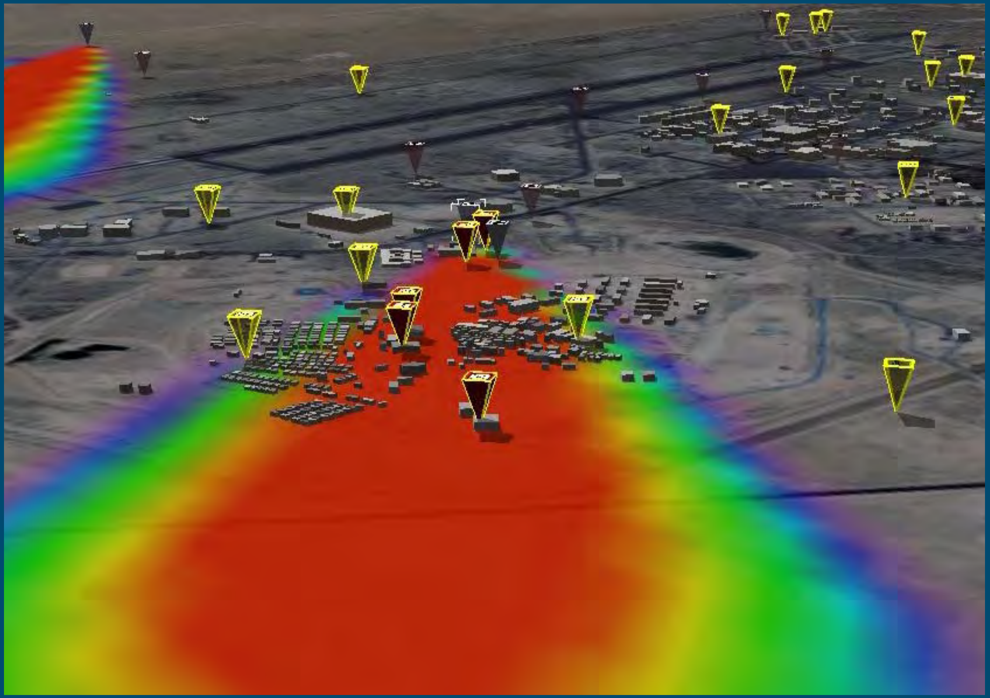
- Dstl's synthetic environment includes
  - model of meandering puffs
  - UDM
  - model of turbulence within puff
  - realistic sensor models
  - biological background model
  - Monte Carlo variation of model parameters



Analysis of data for biological sensor model

Future plans

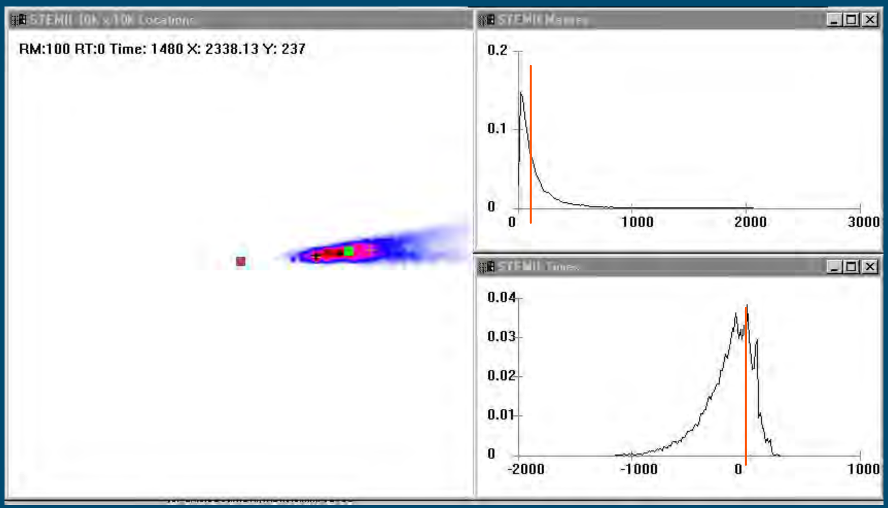
- Completion of sensitivity study
  - what information do we attempt to retrieve?
- Test short-listed techniques in synthetic environment for chemical, then biological releases
  - Biological data fusion complicated by fluctuating biological background
  - quantitative metrics (A_{FN}, A_{FP})



Biological sensor fusion

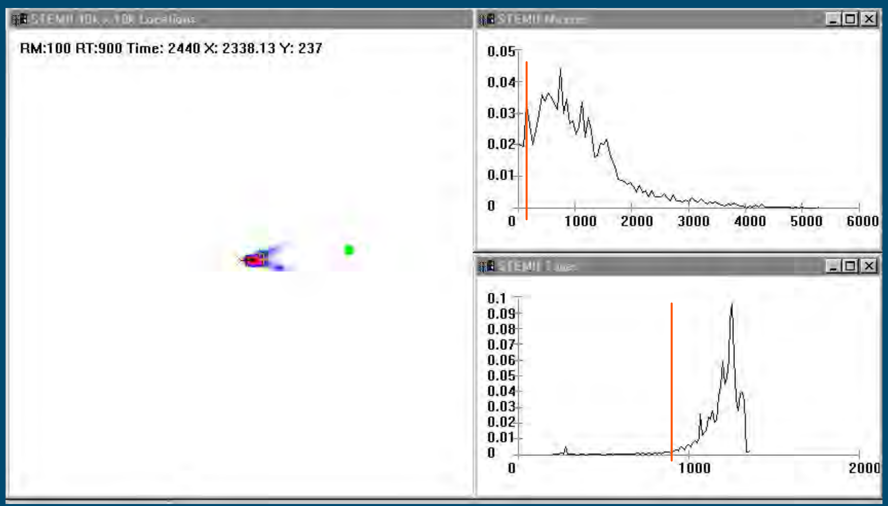
- Biological sensor model

Simple particle counter sensor



Low fidelity, analogue signal

Immuno-Assay detector



High fidelity, digital (2 state) signal

Try to explain better

sion: Information requirements differ depending on decision to be made

CHEMICAL/BIOLOGICAL SOURCE CHARACTERIZATION

Richard Fry – DTRA

R. Ian Sykes – L-3 Titan

Ronald Kolbe - NGIT

S&T CBIS, October 25-28, 2005

OUTLINE

- Background
- Problem
- Previous Work
- Proposed Solutions

Making the World Safer

UNCLASSIFIED

BACKGROUND

- Atmospheric Transport and Dispersion (ATD) Models
- Puff or Plume Models
- Estimate Location and Population Affected
- Key Elements
  - Size and Location of Release
  - Meteorological Data

PROBLEM

- Accidental or Terrorist Release
  - Source is Unknown (Size and Location)

- Therefore Hazard Prediction is Poor

- Identification of Source is Critical

PREVIOUS WORK

- Fundamental Question for Environmental Science
  - Pollution Source Attribution
- Accidental Release
  - Chemical or Nuclear Plant or Transportation Accident
- Solution
  - Large Sensor Grid
  - Use ATD and Limited Sensor Data

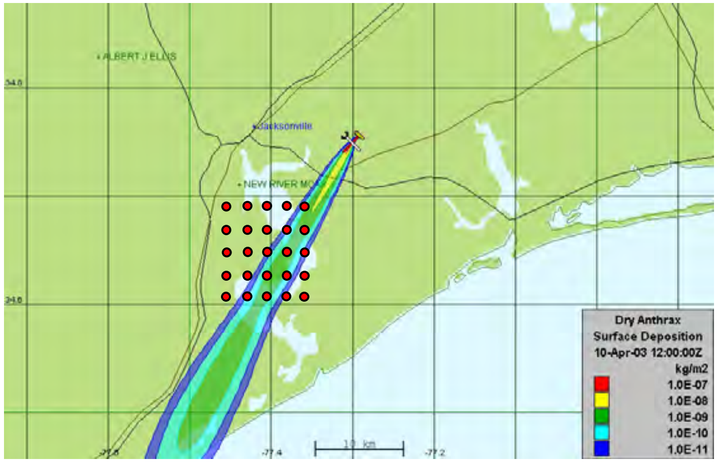
PROPOSED SOLUTIONS

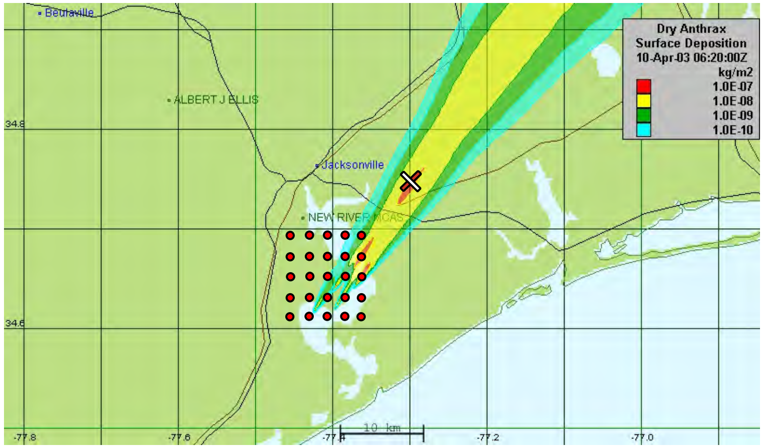
- FORWARD
  - Guess Source
  - Use ATD to Estimate the Hazard
  - Does it Match?
  - Iterate Guess and Recalculate
  - Lots of Runs Required

- BACKWARD
  - Reverse Time
  - Use Sensor Data and Run ATD Backward
  - NOT THAT SIMPLE

BACKWARD METHODS

- Adjoint Transport
- Reverse Diffusion





ADJOINT TRANSPORT

- Concept of Reverse Diffusion is based on the Adjoint Model
- Adjoint provides "inverse" relation between model input (release parameters) and output (sensor measurement)
- Inverse applies for a general class of sensors

ADJOINT TRANSPORT OPERATOR

- For the advection-diffusion equation

$$L(c) = \frac{\partial c}{\partial t} + \frac{\partial}{\partial x_i}(u_i c) - \kappa \nabla^2 c$$

we have

$$L^*(c^*) = -\frac{\partial c^*}{\partial t} - u_i \frac{\partial c^*}{\partial x_i} - \kappa \nabla^2 c^*$$

which can be interpreted as reverse time, reverse velocity, but positive diffusion

GENERAL SENSOR

- KEY TO THE METHOD – Mapping Sensor Response Back to a Source
- Assume sensor output can be expressed as a linear function (weighted integral) of the concentration field

$$S = \int c(\boldsymbol{x},t)\, R^*(\boldsymbol{x},t)\, d^3\boldsymbol{x}\, dt = \left\langle c, R^* \right\rangle$$

where R^* is the sensor response function

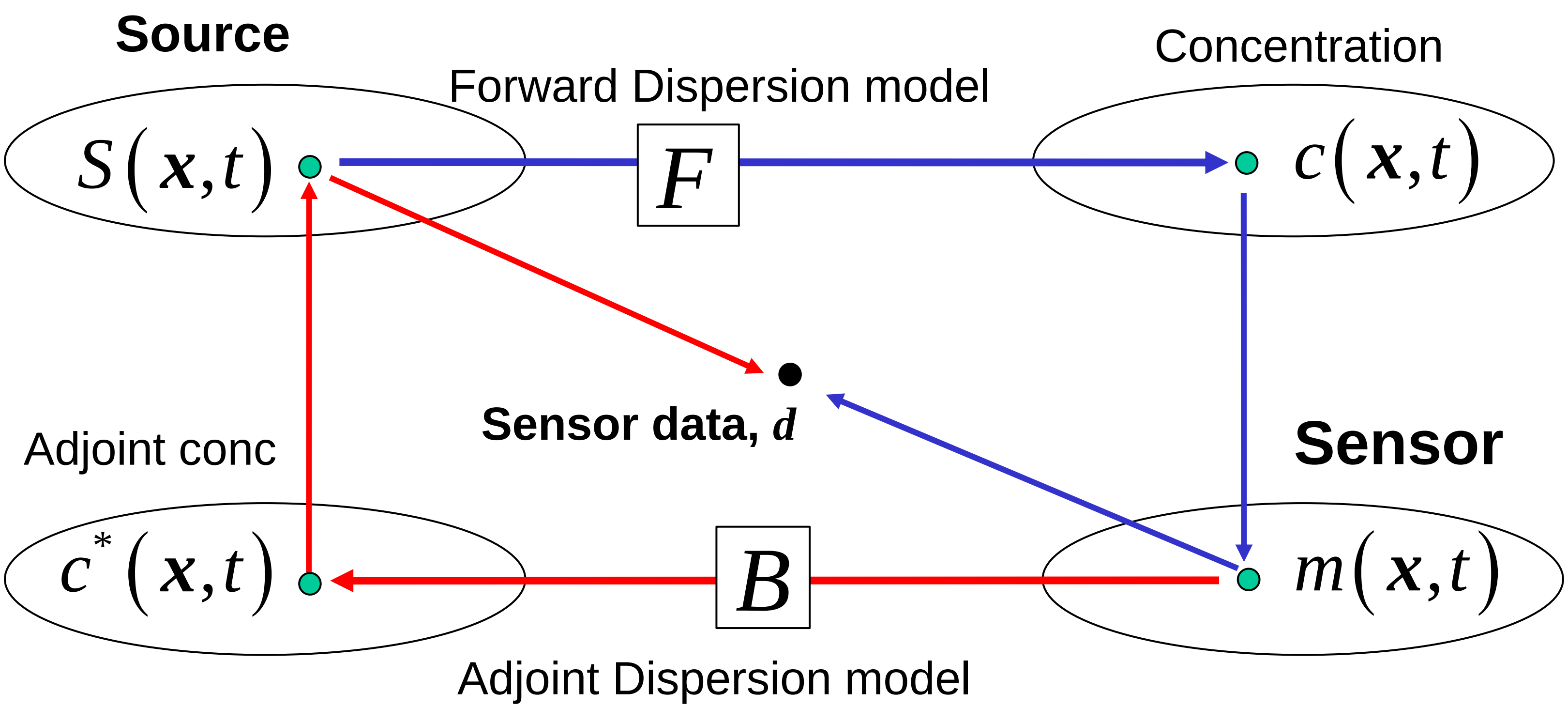
- example is point sensor at $\boldsymbol{x}_0$, t_0 : $R^* = \delta\left(\boldsymbol{x} - \boldsymbol{x}_0, t - t_0\right)$

- Solve Adjoint System: $L^*\left(c^*\right) = R^*\left(\boldsymbol{x},t\right)$

- Adjoint Concentration gives Relationship between Source and Sensor Output

Making the World Safer

ILLUSTRATED SCHEMATICALLY



MULTIPLE SENSORS

- Any sensor data, *S*, defines a complete field (upwind space and previous time) of release mass, *Q*, "possibilities"

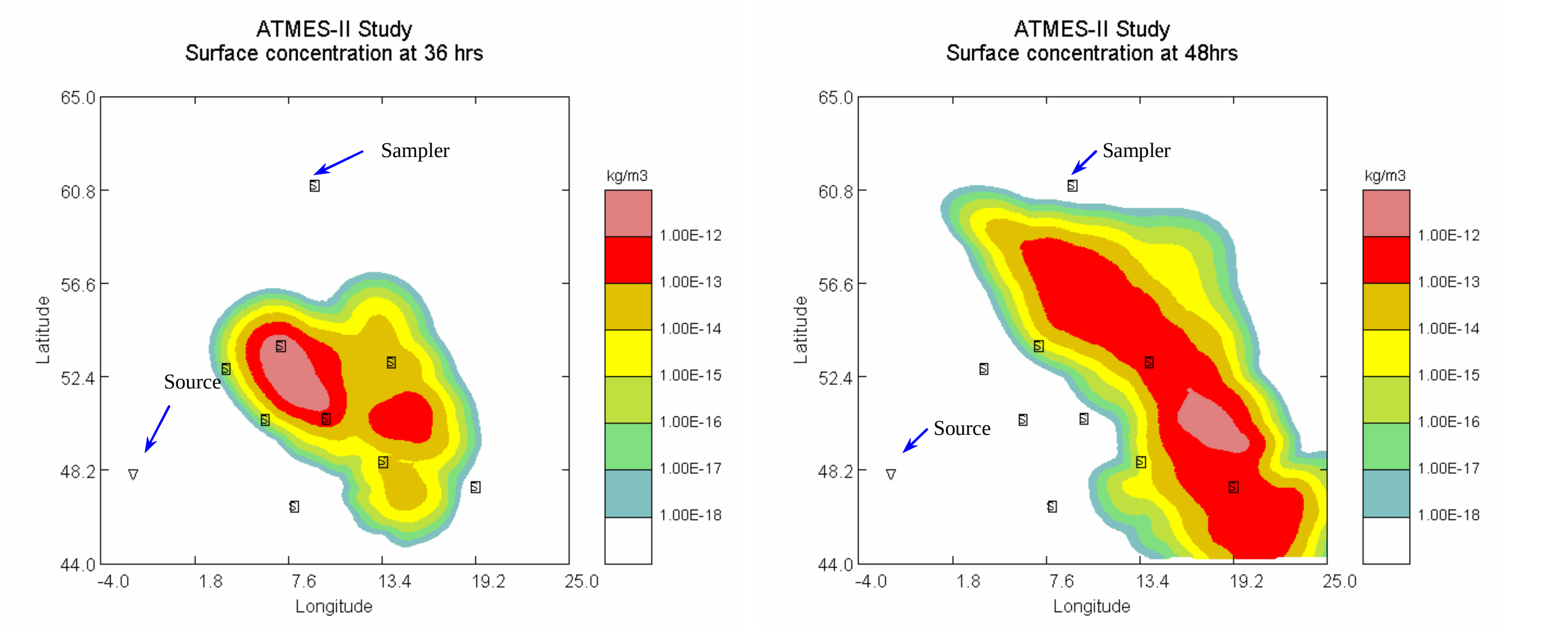
- Use multiple sensors to determine locations of consistency, i.e., same release mass for all sensors

- Note this requires a separate reverse calculation for each sensor measurement

- Release location function
  - need a measure of the range of estimates
  - wider range implies less likely as a release estimate

IDEALIZED CASE

- Use HPAC to generate sensor data for a 4100kg release over 1 hour using ETEX meteorology

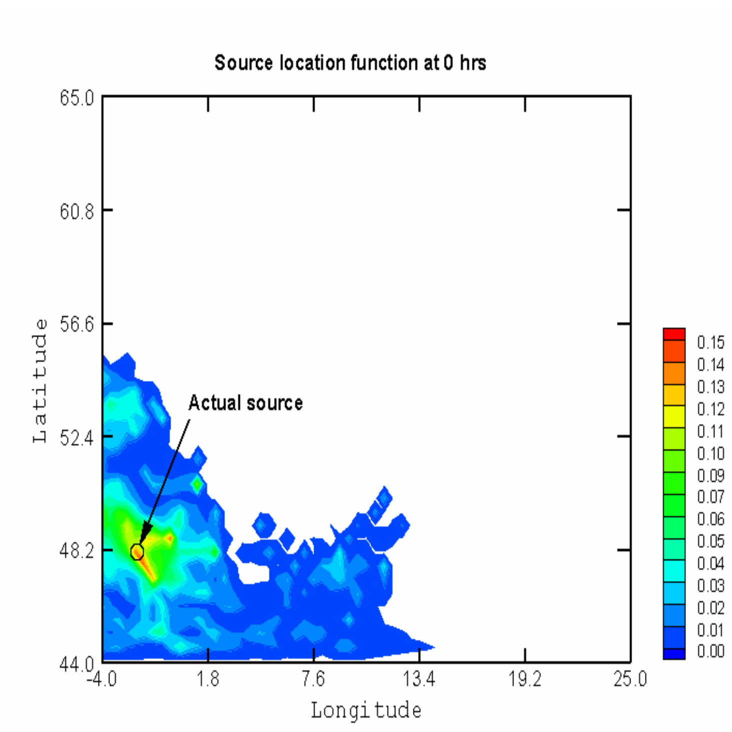


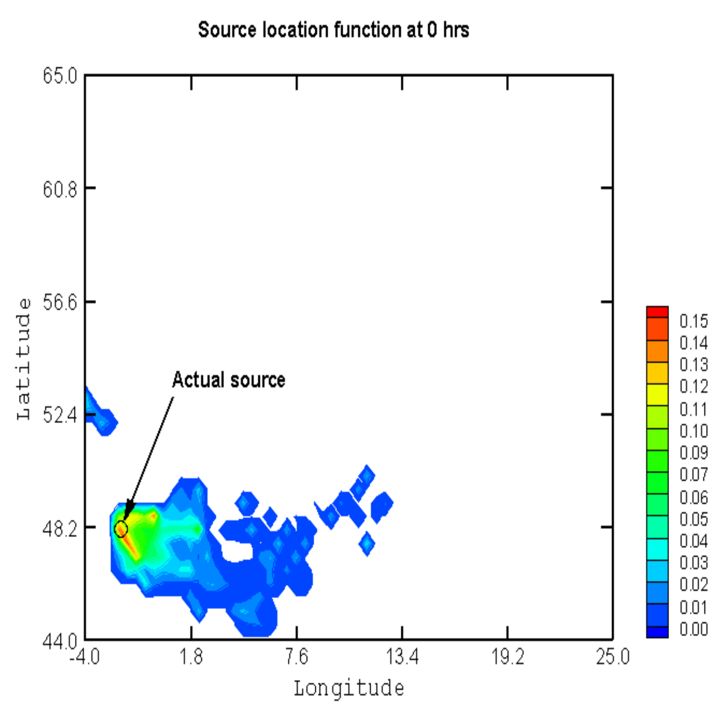
Making the World Safer

UNCLASSIFIED

RELEASE ESTIMATE

- Release Location Function without/with Null data
  - release mass estimate is 2400kg





TANGENT LINEAR ADJOINT

- Utilizes Automated Differentiation
- Uses Cost Function, *J*
- Jacobian of Transport Function

$$\frac{\partial J(\boldsymbol{y}(\boldsymbol{x}))}{\partial x_i} = \sum_k \frac{\partial F_k}{\partial x_i} \frac{\partial J}{\partial y_k}$$

$$\text{or} \quad \nabla_x J(\boldsymbol{y}) = K^T \nabla_y J(\boldsymbol{y})$$

- Refines Initial Source Estimate
- Refines Hazard Prediction

FUTURE WORK

- Generalize sensor and release types

- Investigate probabilistic aspects
  - can we reverse the fluctuation variance equation?

- Investigate Bayesian or other techniques for combining sensor and other data
  - improved definition of source location/strength probabilities
  - multiple source possibility

SUMMARY

- Will Provide Statistical Estimate of Source
  - Location and Strength
  - Improved Estimate of Effective Area and Population
- Proven Science that will provide an Answer

SENSOR PLACEMENT OPTIMIZATION

Science and Technology for Chem-Bio Information Systems

25-28 October 2005

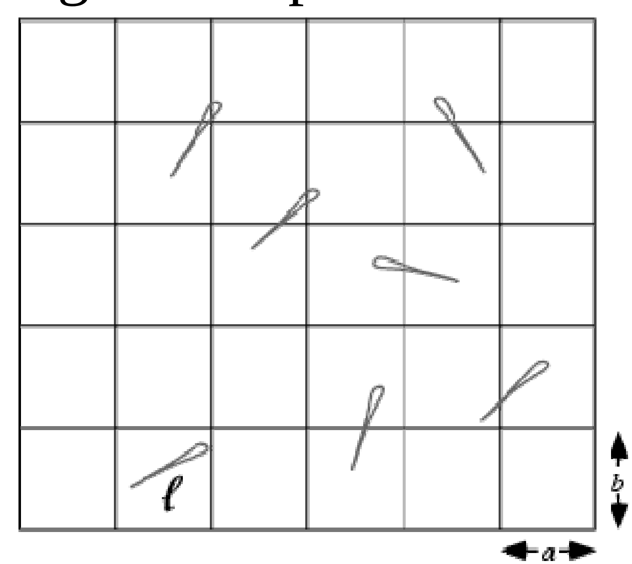
Keith Gardner
Northrop Grumman IT

Problem of Interest

- Multiple Biological detectors to be placed around and within a fixed facility as passive defense measure
- Look at sensor placement options with fast running tool to generate statistical measures
- Definition of performance metric
  - Prior work accepted "at least one hit" on sensor as adequate
  - Relationship between metric and operational use of multiple sensors
  - Consider imperfect attacks
- Overall goal to create optimization tool to determine geometry, spacing and number of sensors

Theoretical approach

- Buffon's Needle: What is the probability that a needle hits crack in floor? It is a function of needle length and space between cracks.



$$P(\ell; a, b) = 1 - \frac{\int_{-\pi/2}^{\pi/2} F(\phi)\, d\phi}{\pi\, a\, b},$$

$$F(\phi) = a\, b - b\, \ell \cos\phi - \ell\, a\, |\sin\phi| + \frac{1}{2}\, \ell^2\, |\sin(2\,\phi)|$$

$$P(\ell; a, b) = \frac{2\,\ell\,(a+b) - \ell^2}{\pi\, a\, b}.$$

If the plane is instead tiled with congruent triangles with sides *a, b, c* and a needle with length *l*, less than the shortest altitude is thrown, the probability that the needle is contained entirely within one of the triangles is given by

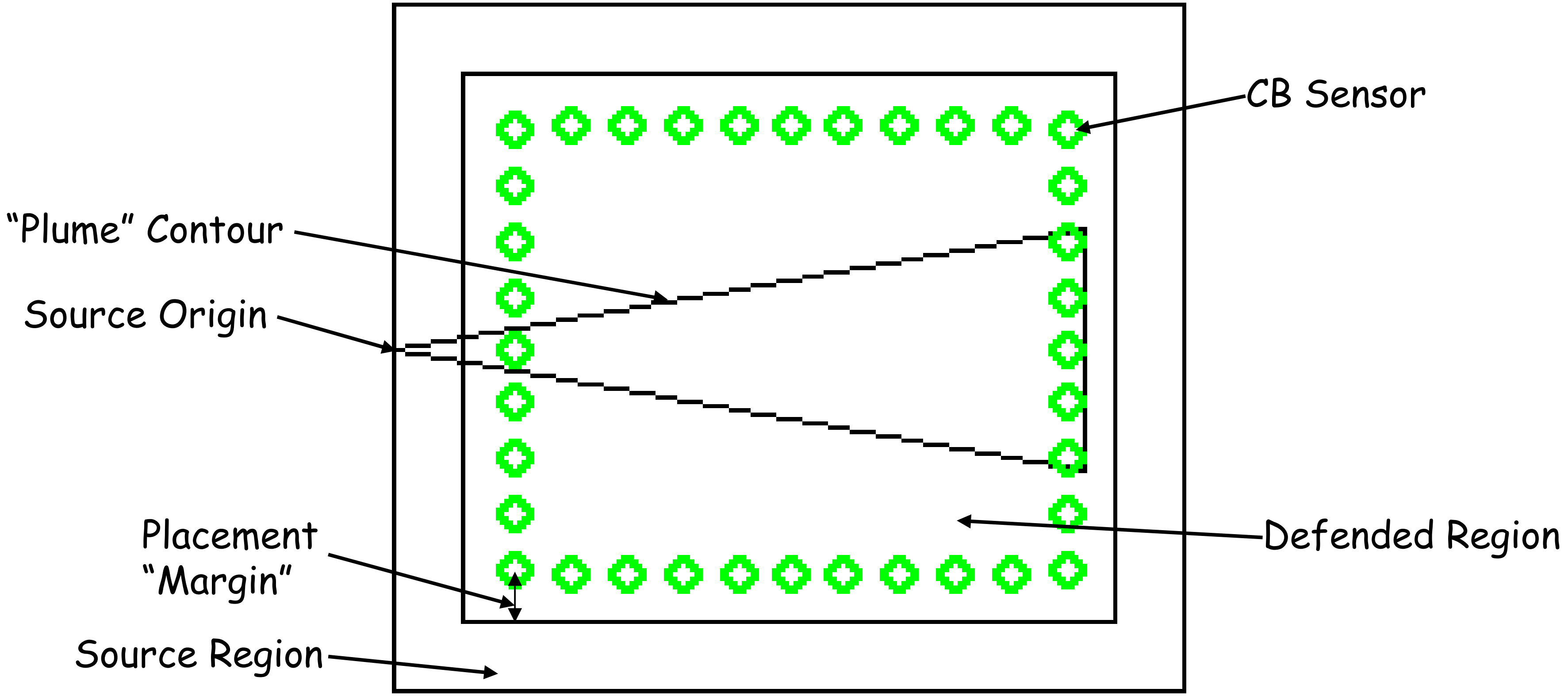
$$P = 1 + \frac{(A a^2 + B b^2 + C c^2)\ell^2}{8\pi K^2} - \frac{(4a + 4b + 4c - 3\ell)\ell}{4\pi K},$$

Where *A, B* and *C* are the angles opposite *a, b* and *c* respectively, and *K* is the area of the triangle.

What about dropping triangles on points, like a deadly plume on a sensor field? Too difficult – try a simulation.

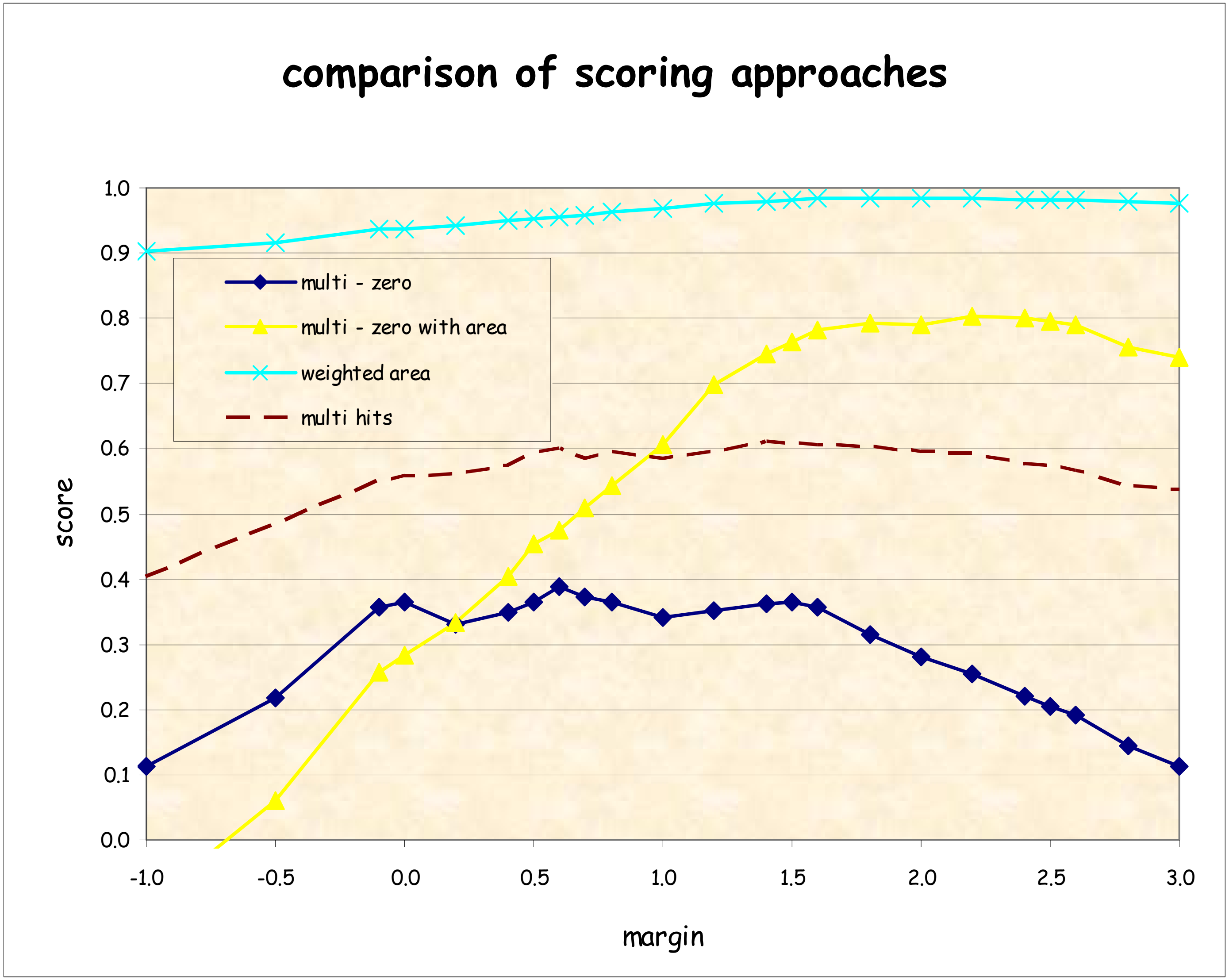
Mathworld.wolfram.com

Example Configuration

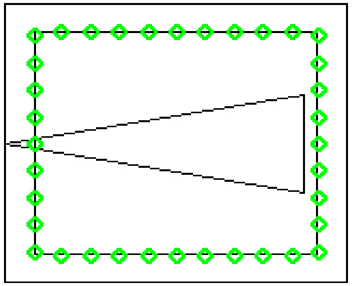


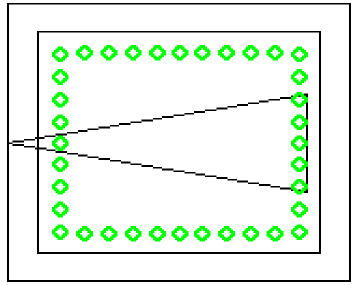
Basic Scoring Approaches

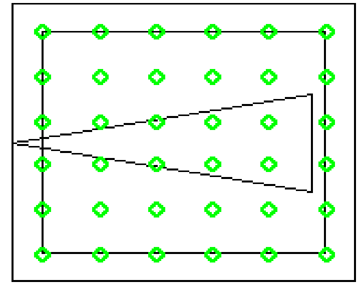
- Count number of detections
  - **Score =** number of detections
  - Problems: unbounded, had to compare different size arrays; sensitivity
- One or more hits is good (war posture, false alarms not considered)
  - **Score =** number of runs with one or more hits / total number of runs
- More than one is better (homeland posture, avoid false alarms)
  - **Score =** number of runs with two or more – number of runs with zero hits / total runs
- Areas weights =>> score * plume area / base area
  - Values cases where plume covers center of defended region
- Power law weights (optimization routine, declining return)
  - **Score** = $(2^i-1)/2^{(i-1)}$ or {0, 1, 1.5, 1.75, .. => 2.0}
  - Allows additional weight (discrimination) for more hits

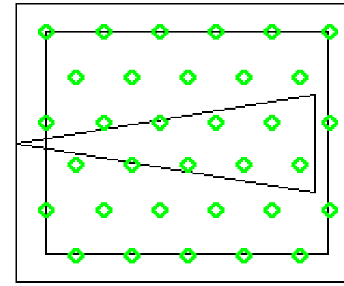

comparison of scoring approaches
multi - zero
multi - zero with area
weighted area
multi hits
score
margin
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0

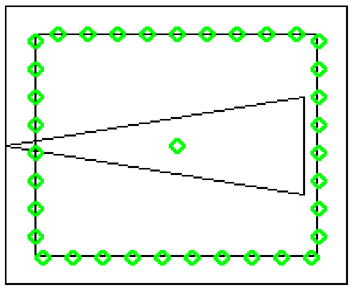
Grid Configurations

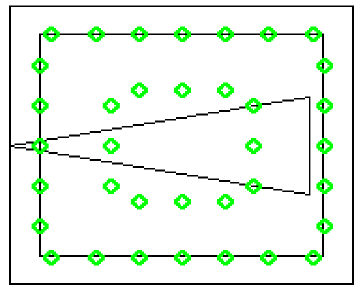

Perimeter

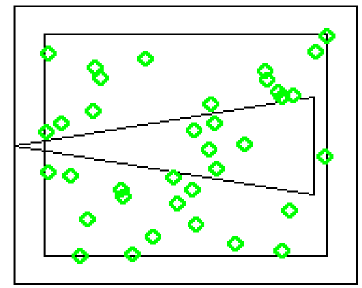

Perimeter with Margin

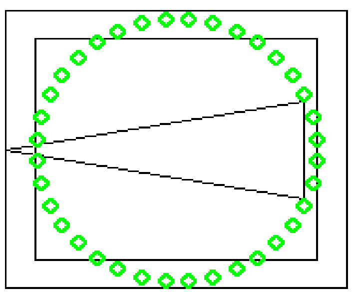

Uniform Array

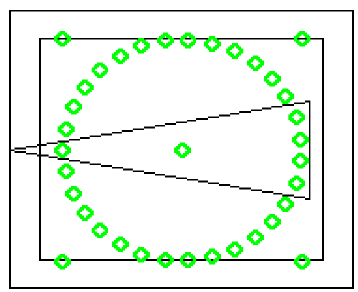

Dice 5

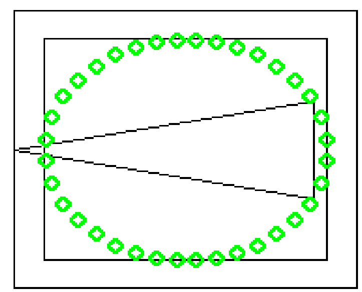

Perimeter with Center


Perimeter - 2 Tiers


Random

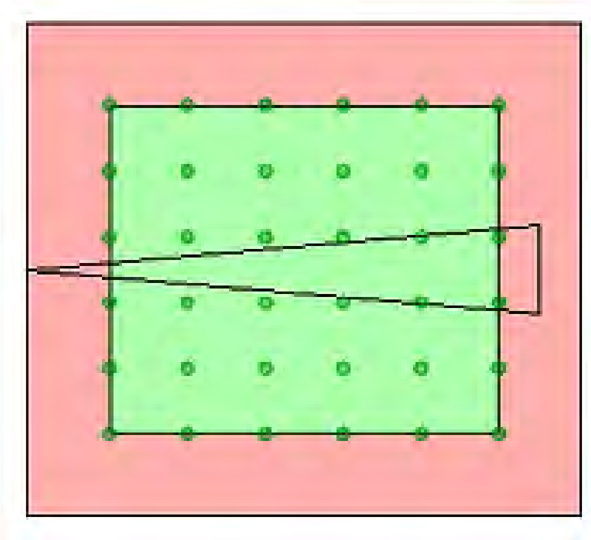

Circle

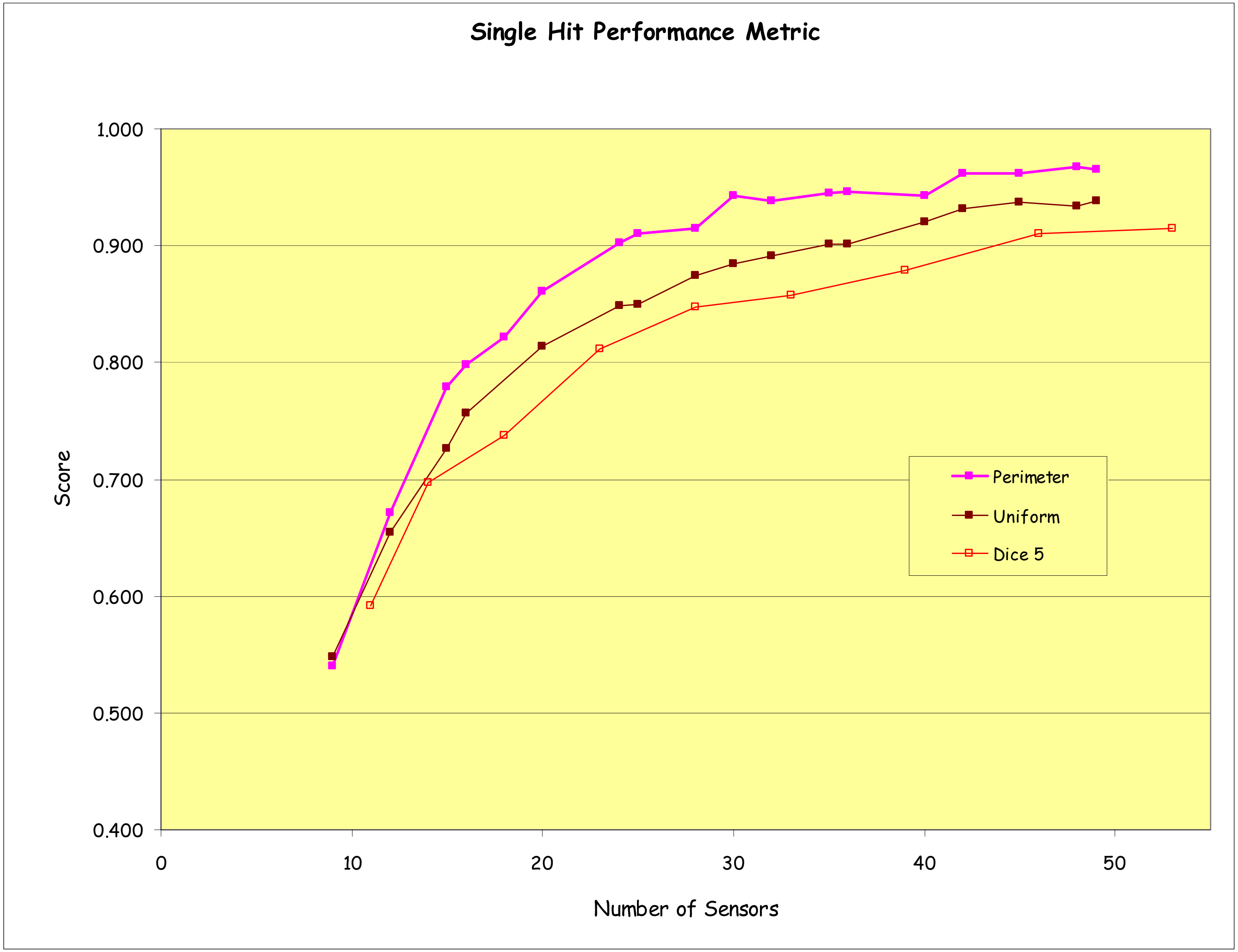

Circle, Margin, Center, Corners

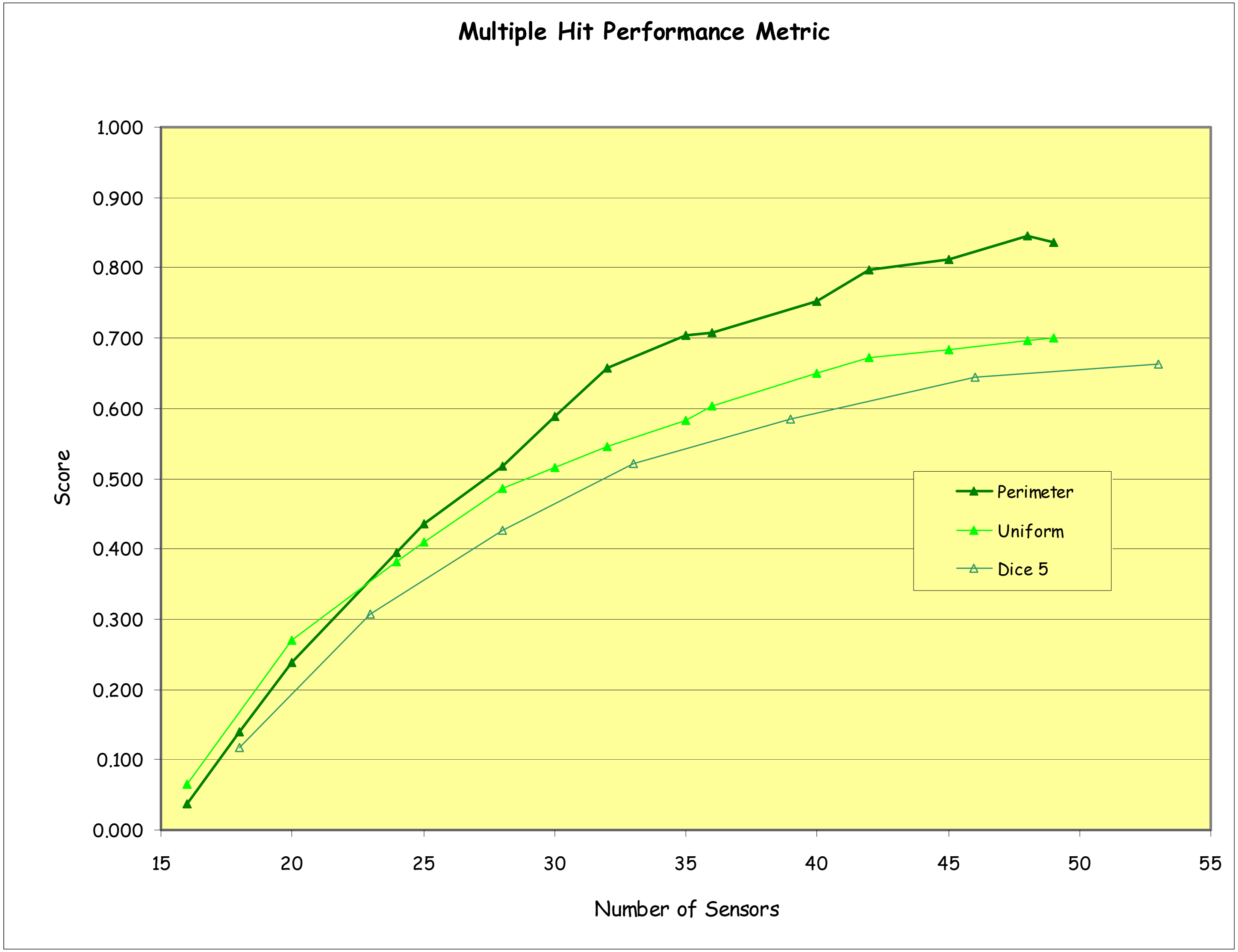

Ellipse

Scenario Parameters

- Defended Region: 16 km x 19 km
- Plume Source Region: 24 km x 27 km, centered on Defended Region
- Plume: 25 km length, 10 degree arc width
- Scenario Control: 2500 trials per run, fixed seed
- Sensor Configuration: Margin = 0.0

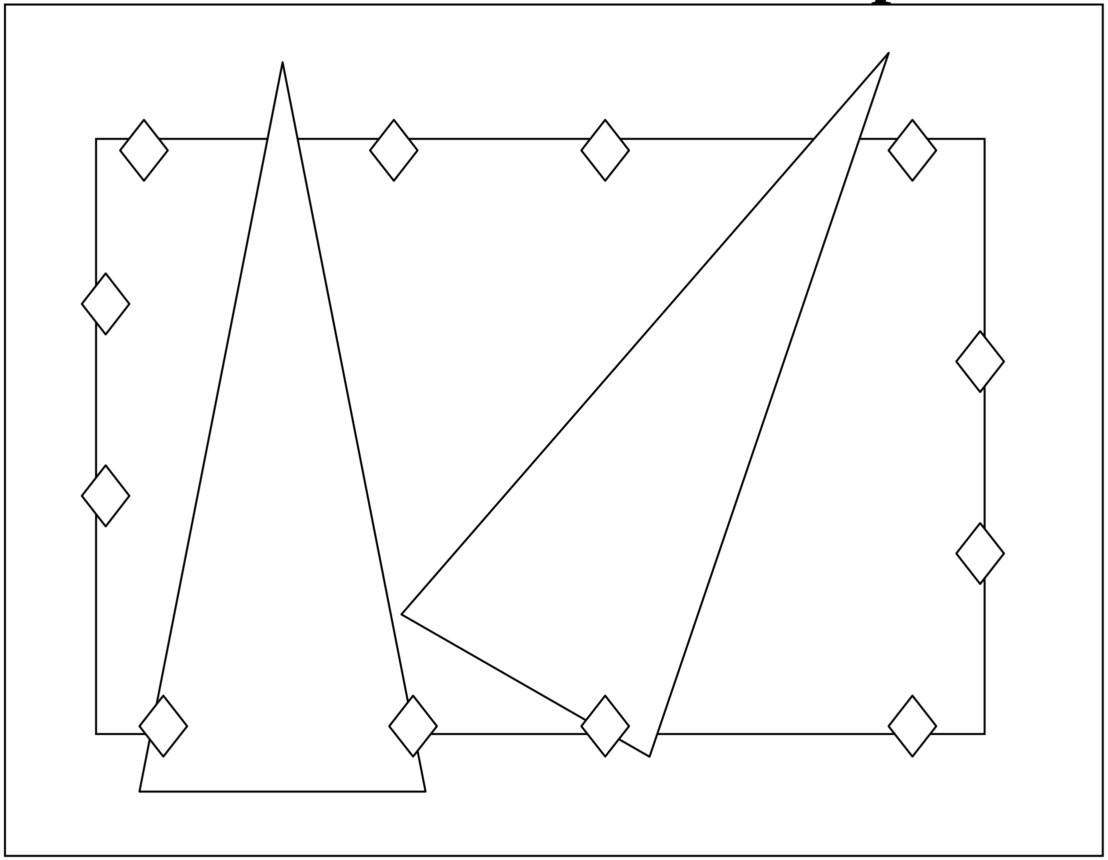



Single Hit Performance Metric
1.000
0.900
0.800
0.700
0.600
0.500
0.400
Score
0
10
20
30
40
50
Number of Sensors
Perimeter
Uniform
Dice 5



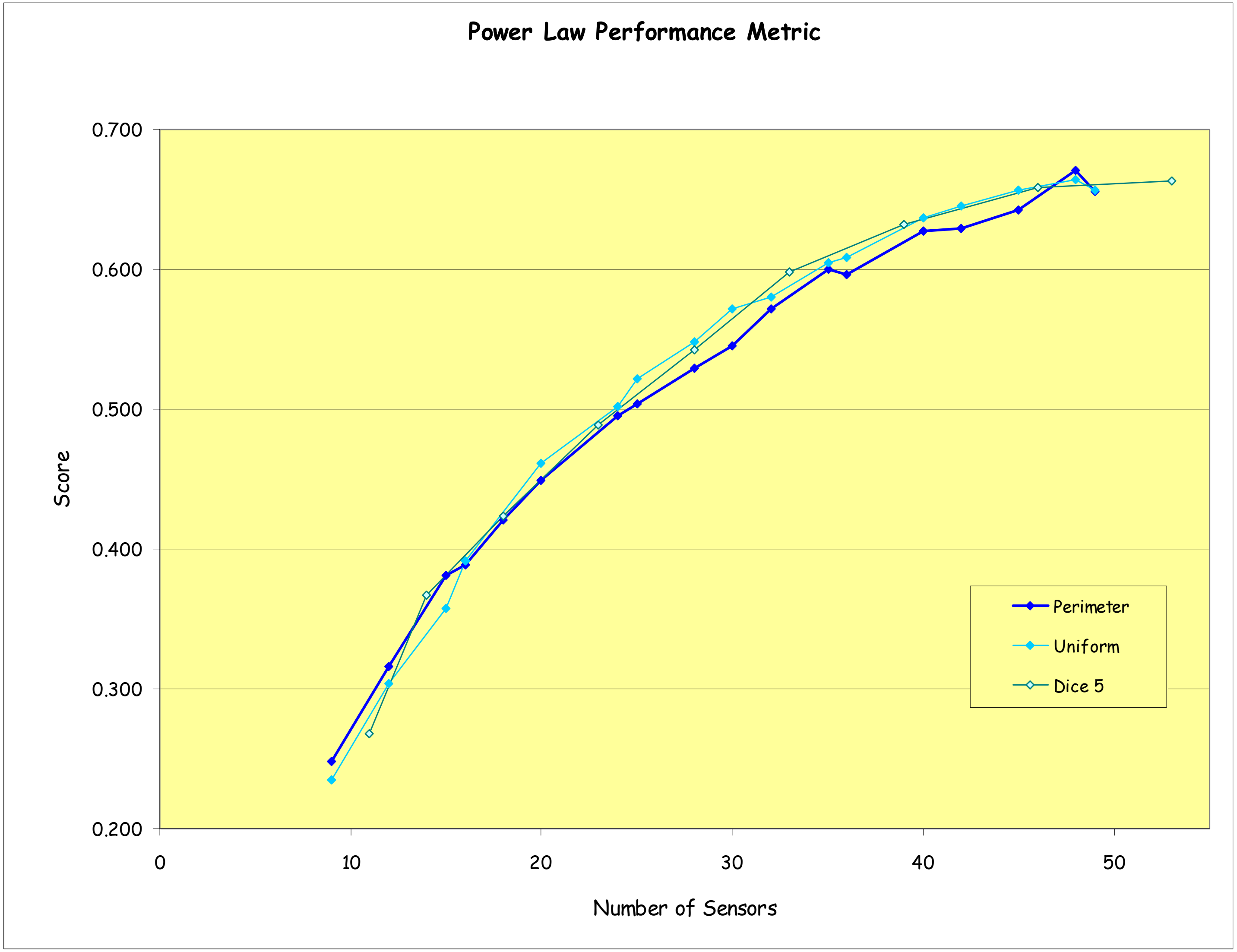
Making the World Safer

Perimeter vs Uniform for multiple hits

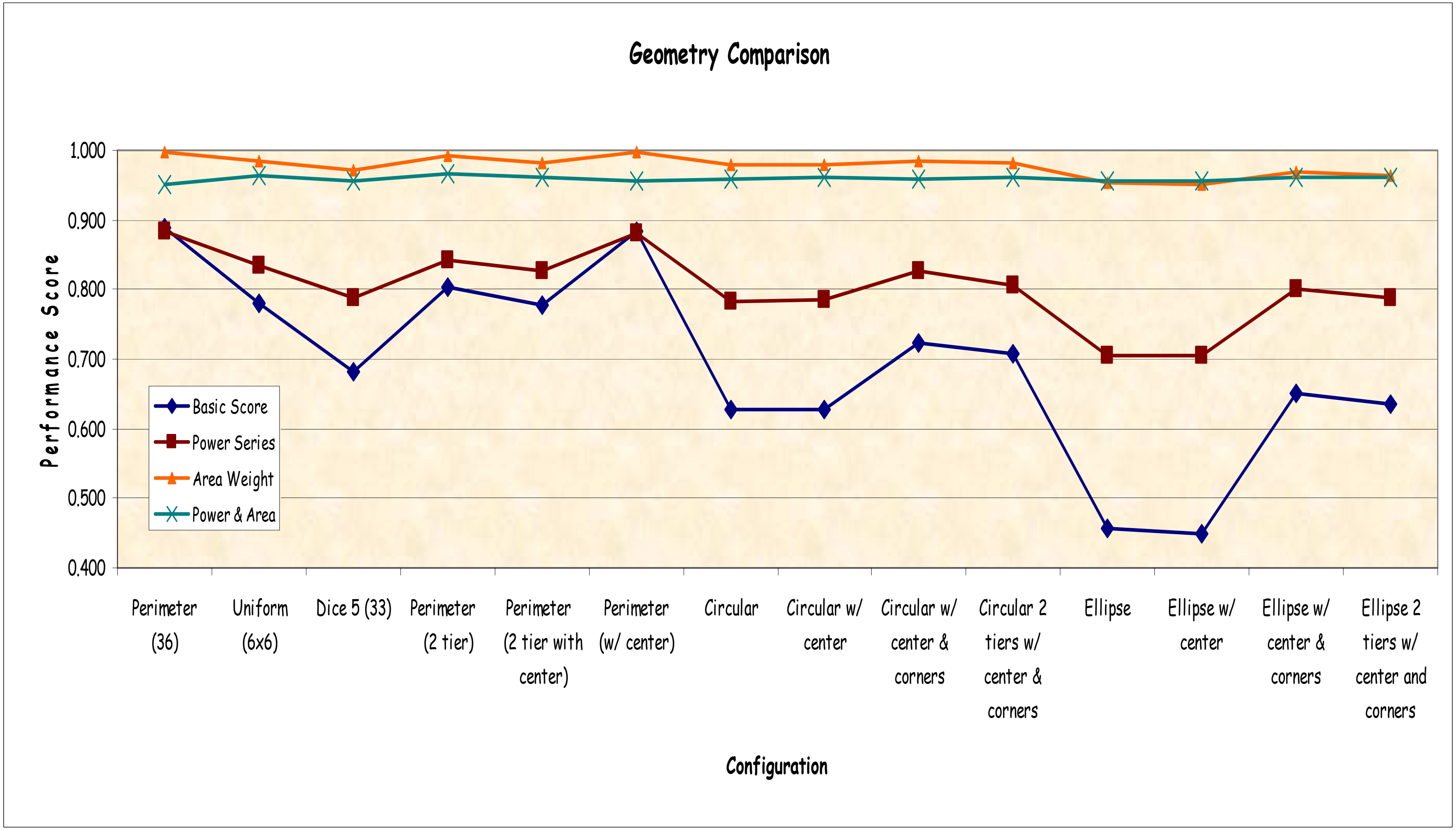


If the sensors are far apart, it is difficult to hit two or more with Perimeter.

Uniform is preferred with limited sensors.



Power Law Performance Metric
0.700
0.600
0.500
0.400
0.300
0.200
Score
0
10
20
30
40
50
Number of Sensors
Perimeter
Uniform
Dice 5



DTRA
Making the World Safer

Observations

- Dice 5 configurations offer no advantage over uniform arrays
- Configurations that conform to defended region “work better” than configurations that don’t conform
- Perimeter geometries and uniform arrays have a crossing point as number of sensors is increased
- Scoring system must take into account tactical motivations, false alarms, forensics, etc.
- Optimization using Tabu search should be able to optimize margin, spacing and number of sensors for a given area, especially with warm start provided by this tool

Future Areas for Study

- Optimization of sensor placement
  - Spacing (wind), geometry (spiral), margin, number, cost, performance
  - More realistic sensor performance/ Mixed sensitivity
- Chemical versus Bio plume size consideration
  - Topology, terrain, day/night, etc.
- Quantitative specification of perimeter/uniform cross-over point
- Non-rectangular defended regions

S&T for Chem Bio Information Systems General Session

Wednesday, 26 Oct

8:30-8:35	Admin Remarks
8:35-9:10	Agent Fate Program
9:10-9:30	Decision Support Program
9:30-9:50	Research Development and Engineering Command (RDECOM)
9:50-10:20	**Break** *& Joint Project Manager Information Systems Demo*
10:20-12:00	Begin Breakout Sessions (Breakout Session A)

DTRA - Modeling and Simulation/Battlespace

BO05MSB070: Multivariate Decision Support Tool for CB Defense

DTRA University Strategic Partnership

Gold Team

Frank Gilfeather, UNM

October 26, 2005

CB Defense Decision Support Tool

Purpose:

Provide an expert decision-support system to assist decision makers in allocating Science & Technology (S&T) research funding to reduce the threat and consequences of CB attacks on critical assets

- *Troops in the field*
- *Main operating bases (MOBs)*
- *Warships*
- *Embassies*
- *Ports*
- *Commands*

Acknowledged as a difficult problem with great potential, and with no clear solution

CB Defense Decision Support Tool

University Partnership Team

UNM – Frank Gilfeather, Thomas Caudell, Panaiotis, Tim Ross, Mahmoud Taha

NMSU – Jim Cowie, Chris Fields, Hung Nguyen , Bill Ogden, Ram Prasad

MIIS – Gary Ackerman, Markus Binder, Sundara Vadlamudi

Historians
Biochemists
Knowledge engineers
Cognitive Psychologists
Scientists
Engineers
Mathematicians
Political Scientists
Economists
Computer Engineers
Artists

Goal in year one

Develop a R&D Plan to Build a Multivariate Decision-Making System

Specifically:

Outline an Architecture for *CB Defense Investment Decisions* that provides:

- *Capability Assessment*
- *S&T investments Prioritization*
- *S&T Resource allocation decisions*

Perform Technique Assessments that include:

- *Strawman Applications Development*
- *Processes Validation*

Engages a broad-based team of creative professionals

Design Goals

- Develop the analytic and algorithmic framework for a tool that assists decision-makers who create funding portfolios intended to minimize threat-consequences.
- Create a feasible system architecture to evaluate modeling, analysis approaches, and user interactions within this framework.

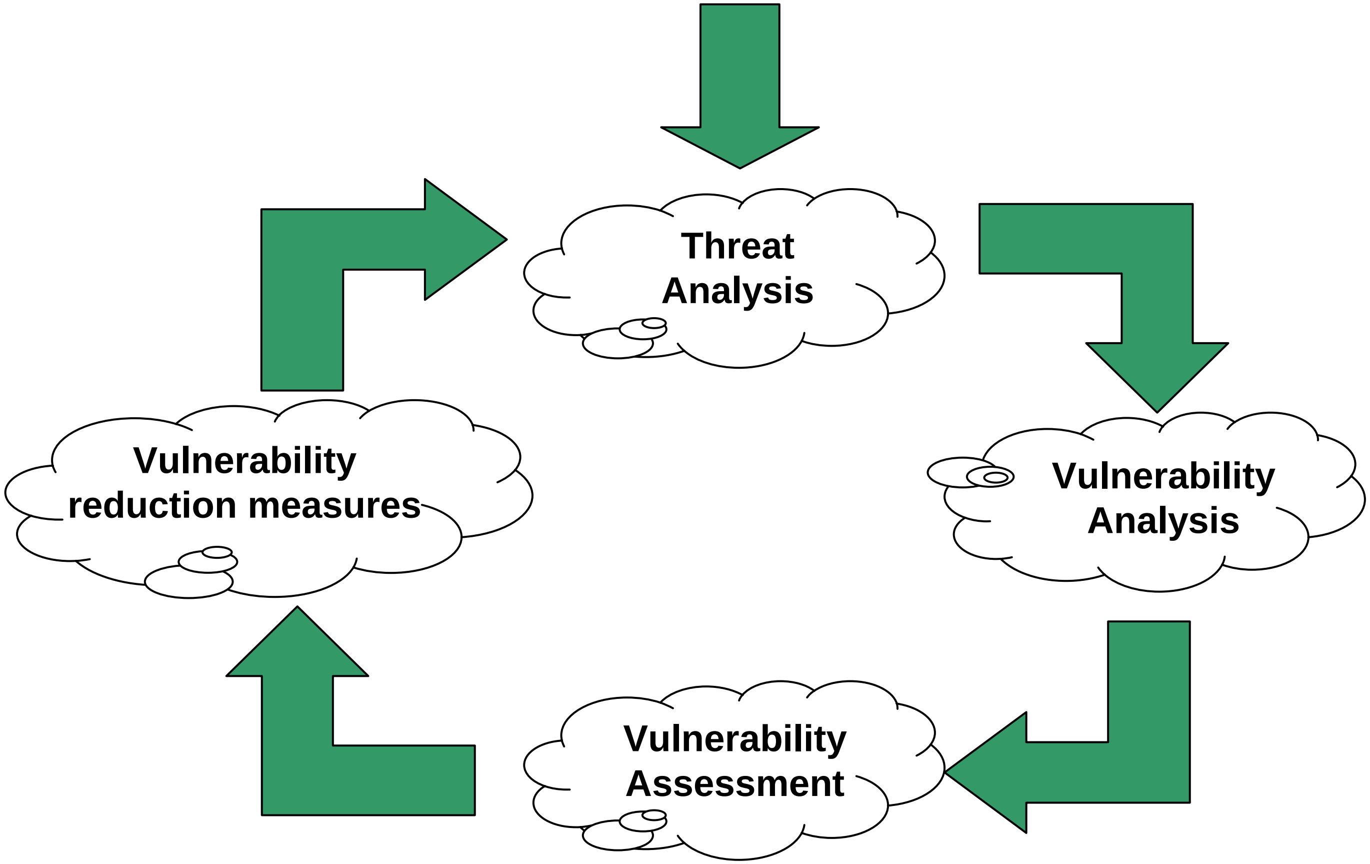
Ultimately: A usable and flexible DS tool

Design Philosophy

- *Utility to the decision maker*
  - Tied to key user profiles
  - Flexible in use
- *Transparency, not a black box*
  - Shows the evolutionary process of derived outcomes
  - Illustrates cause and effect relationships through visualization
- *Looking for "unexpected outcomes"*
  - Adds information – not just obvious outcomes
  - Minimizes the effect of preconceived notions and biases
  - Provides new ideas and perspectives of the problem space
- *Tuning is evolutionary*
  - Capable of correcting and learning from false outcomes
  - Tool improves with use

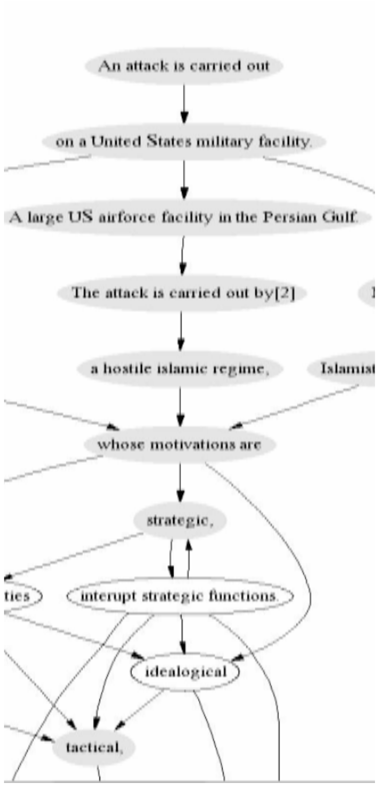
Transparency is paramount

Aligning tool with CB Vulnerability Reduction Process (FM 3-11.14)



Goal is to provide iterations for analysis

Specification of Incident Scenarios



- Discrete Possibility Tree (ala LED @ LANL)
- CBRN Data Model used
- Spanning set of incident scenarios (IS)
- Vector of consequences per scenario
- Possible continuous IS space
- Possible continuous consequence space
- Threat Analysis, Vulnerability Analysis, and Assessment are integral to the Incident Scenario space

Incident Scenarios were developed for use in our model and are key to FY06 effort

Threat and Incident Characterization
Incident Scenario Tree

- Incident scenarios:
  - Threat analysis
    - Characteristics - type
    - Attacker objectives
    - Site selection – typical and special sites
  - Vulnerability analysis/risks:
    - Site characteristics
    - Site readiness
  - Vulnerability assessment/consequences:
    - Extent of mission disruption
    - Casualties
    - Length of disruption
    - Collateral damage
    - Geo-political impact
  - Vulnerability Reduction - mitigation costs and effectiveness
- Incident data for analysis:
  - Expert input and simulation
  - Existing data from sites
  - Site survey and analysis

An Incident Tree based on the LANL LED program schema will determine a large set of incident scenarios from which risks (based on impact selection) will be assigned by experts.

Effects/consequences from each selection combination is an incident with a set of incident data including risk data.

Related talks:

- ***Dr. Steve Helmreich, etal., 2:30, Wed***
- ***Dr. Ram Prasad, etal., 3:30, Wed***
- ***Gary Chevez, etal., 8:35, Th***

Vulnerability Reduction
S&T Mitigation and Cost

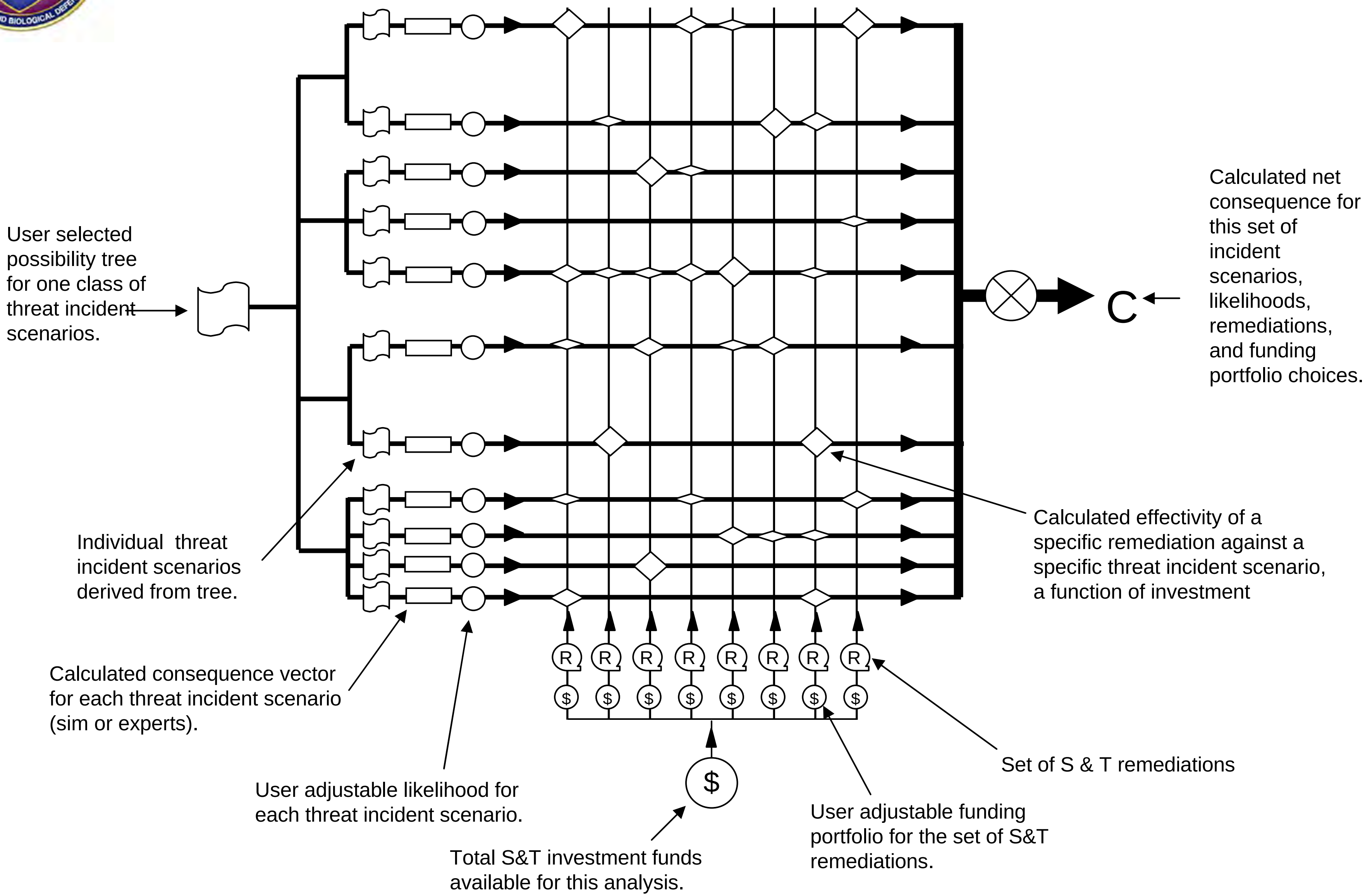
- Options
  - Current site plan status
  - COTS options - combinations
  - S&T options - combinations
- Cost of Options
  - deployment and
  - operation,
  - effectiveness,
  - time to deployment,
  - etc

User adjustable funding portfolio for the set of S&T vulnerability reductions

S&T costs and mitigation effects from each incident yields a set of S&T/incident data impacting and altering the risks from that incident

Initial Architecture

No Temporal Dynamics – First Generation

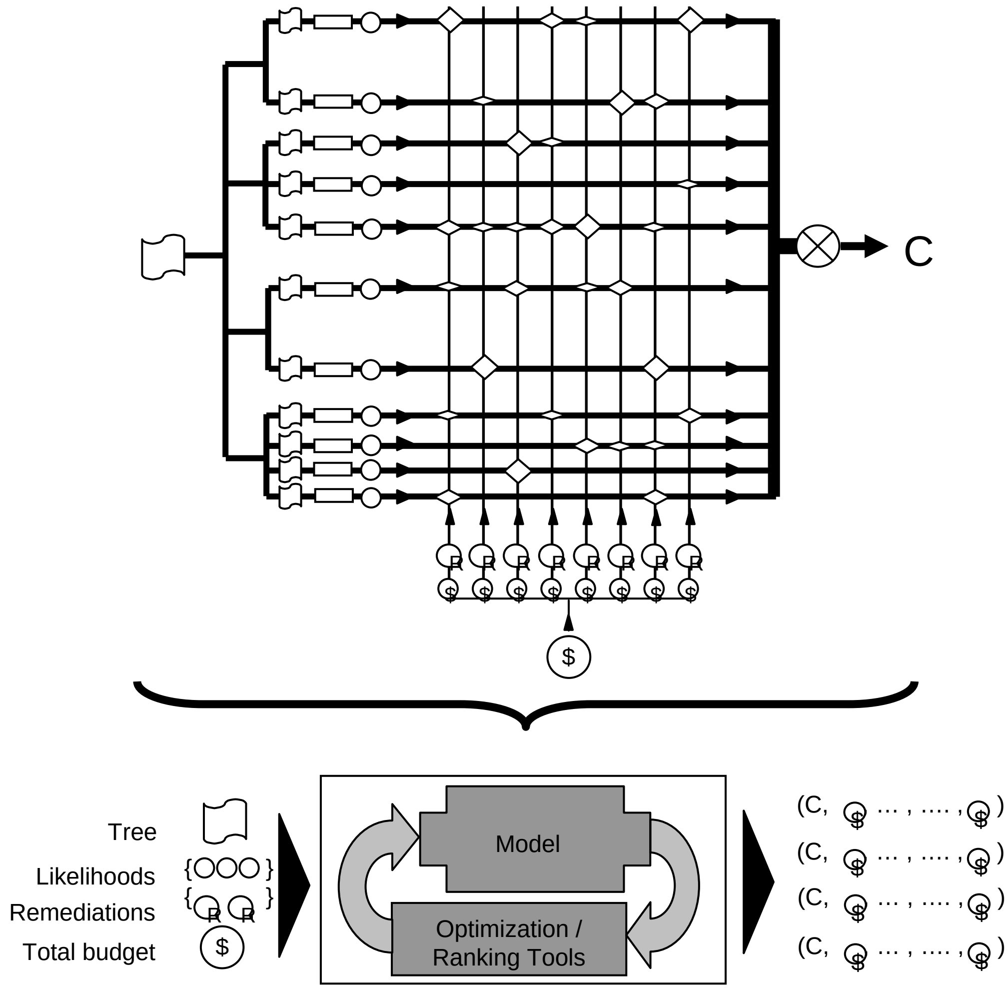


Creating Models of Costs and Effectiveness

- Relates remediation funding level to effectiveness against a given IS-scenario's consequences.
- Simulation
- Expert examples
- Interpolation using machine learning
- Knowledge based systems

Analysis, recently initiated, will be a major effort for FY06

Optimization Loop



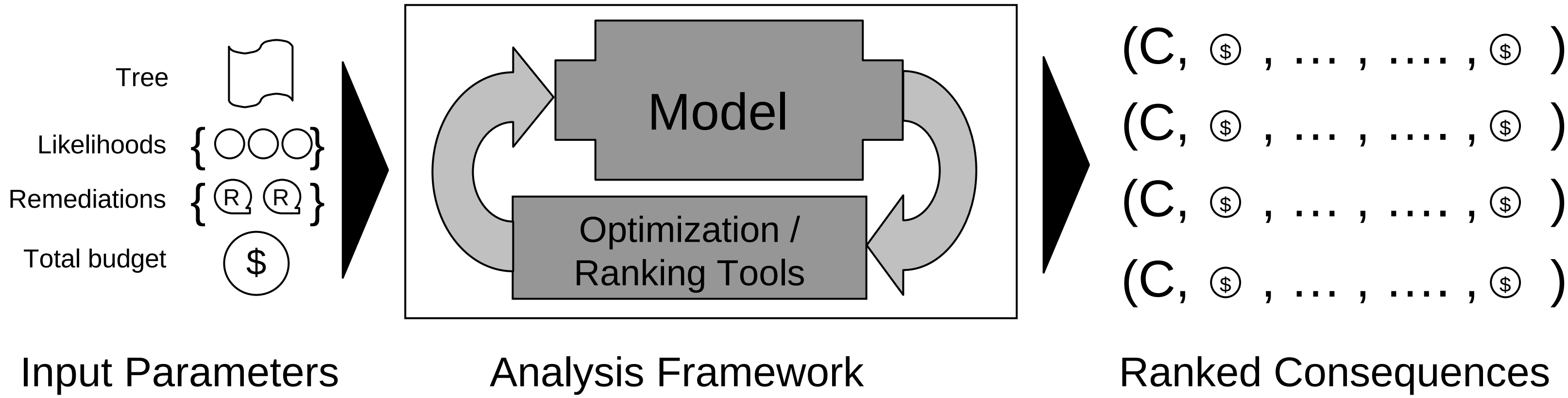
Input Parameters

Analysis Framework

Ranked Consequences

Optimization

Allocation of funds to minimize expected consequences

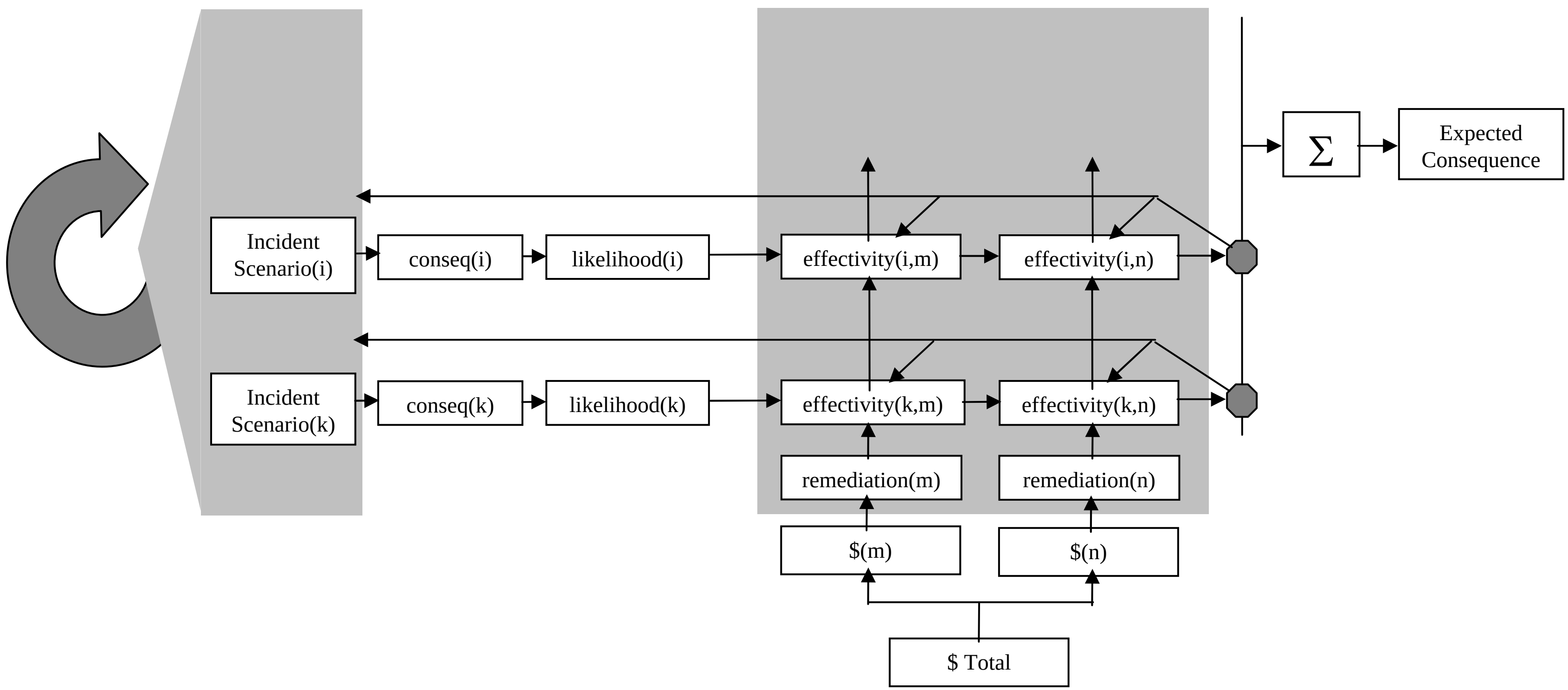


We analyzed existing optimization and ranking tools for their relevance to the problem space

Related talks:

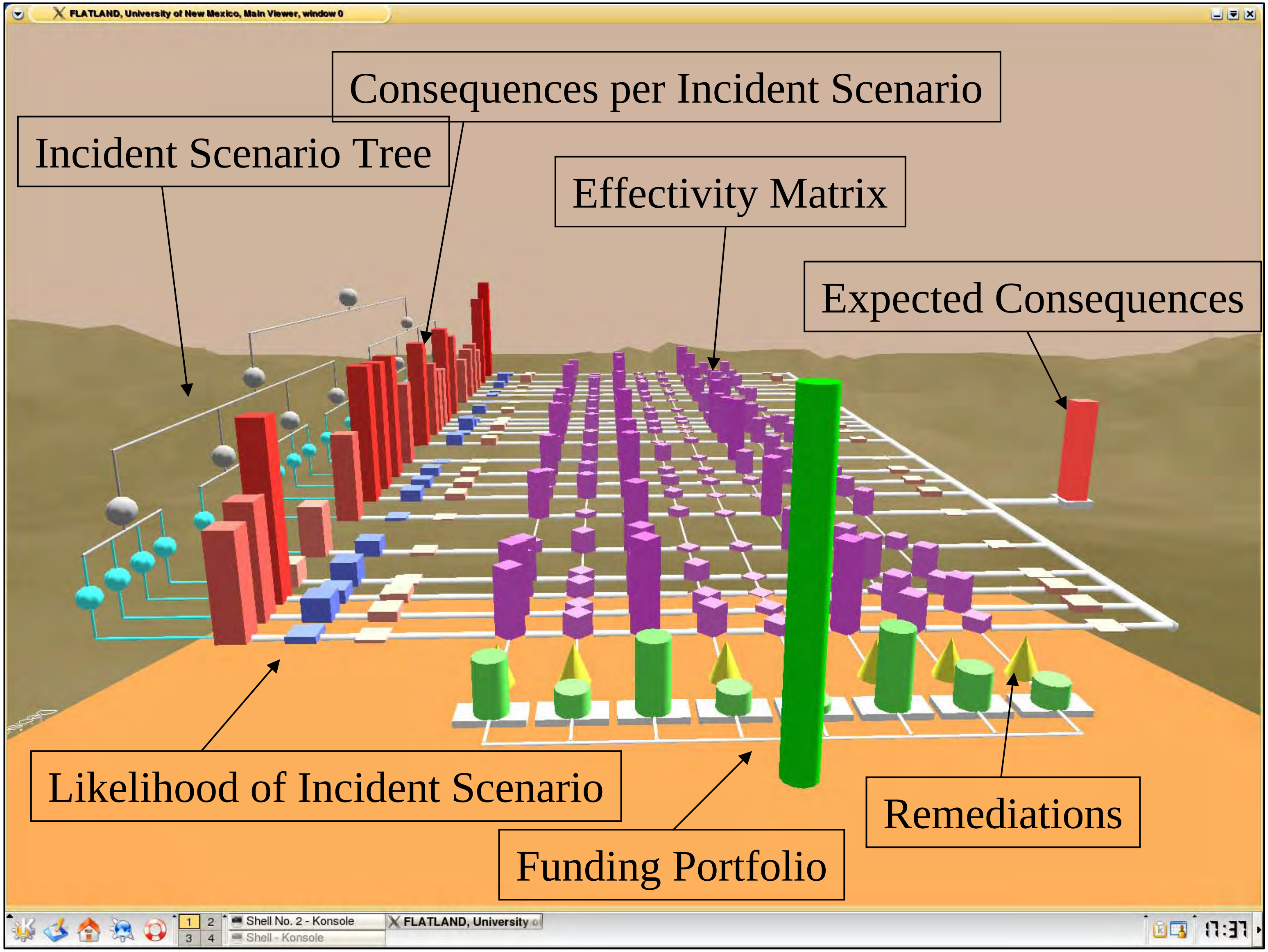
- ***Dr. Hung Nguyen, etal., 4:30, Wed***
- ***Dr. Roshan Rammohan, etal., 9:30, Th***

Temporal Dynamics



Temporal Dynamics is part of 2nd generation framework with implication for model in FY06

Visualization of Mockup System (1st Generation)



Visualization Features

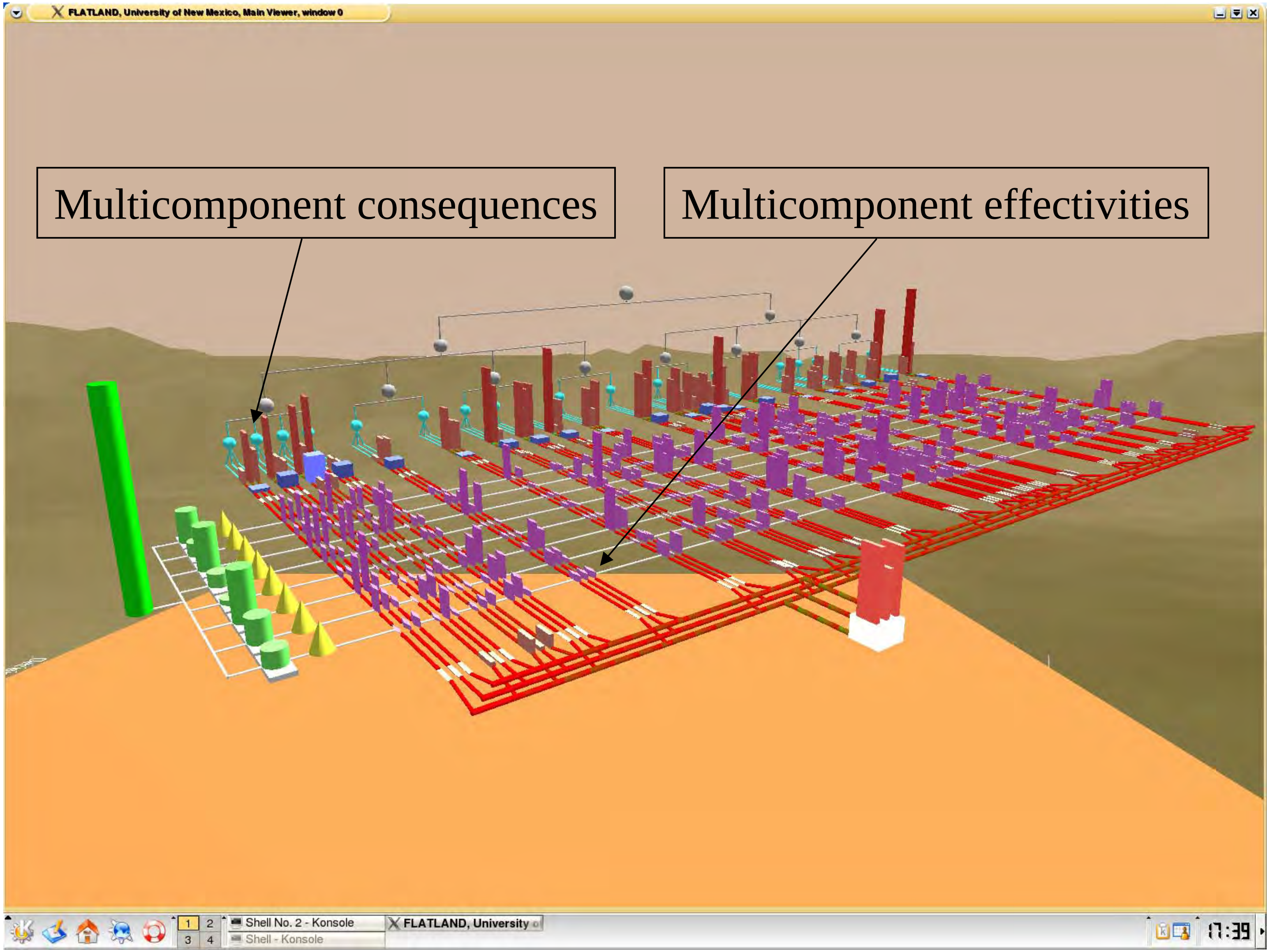
- Complete visibility into computational model
- Multi-sensorial approach increases comprehension
- Consequence-flow metaphor
- Real-time user adjustable parameters
- Multi-resolution to manage complexity
- Drill-down for more details
- Animation of calculations and optimization

Visualization interface provides flexibility and transparency

Related talks:

- ***Dr. Tom Caudell, etal., 2:00, Wed***
- ***Dr. Panaiotis, etal., 9 AM, Th***
- ***Bill Ogden, etal., 4:00 Wed***

Visualization of Mockup System



FY06 Effort

- Refine Framework – 2nd Generation
  - Incident Scenario (IS) framework and representation trees – define and tie to CBRN data model
  - Remediation and cost representations – define and analyze
  - Effectivity representations – define and analyze
  - User profiling – provides for multiple user-types
  - Temporal issues – define and embed
  - New complex analysis tools developed as framework evolves
- Mock-up Tool
  - Provide a limited working model
  - Match analysis tools to specific use
  - Test and obtain user assessment
  - Consider potential of wider use

William J. Ginley
Battlespace Management Thrust Area Manager
Edgewood Chemical Biological Center
25 October 2005

CB Defense Battle Management

Data Fusion, Indication and Warning (FIW) — **CB Defense Battlespace Management** — **Automated Decision Support (ADS)**

- Data Fusion
- Warning
- Alerting
- Situational Awareness
- Information Presentation
- CB Data Standardization

- Decision Support Software
- Data Mining
- Information Filtering
- Communications

- **Making it easier for the warfighter to use what we develop!!!!**

Thrust Area Foci

Data Fusion, Indication and Warning (FIW)

CB Defense Battlespace Management

Automated Decision Support (ADS)

Data Fusion, Indication and Warning (FIW):

- **<u>BAA05MSB0009</u>: CB Weapon Environment Prediction: Fusion of Sensor and Model Data (6.2)**
- **Rapid Response Database Center (6.2)**
- **Rapid Response Sensor Networking (6.2)**

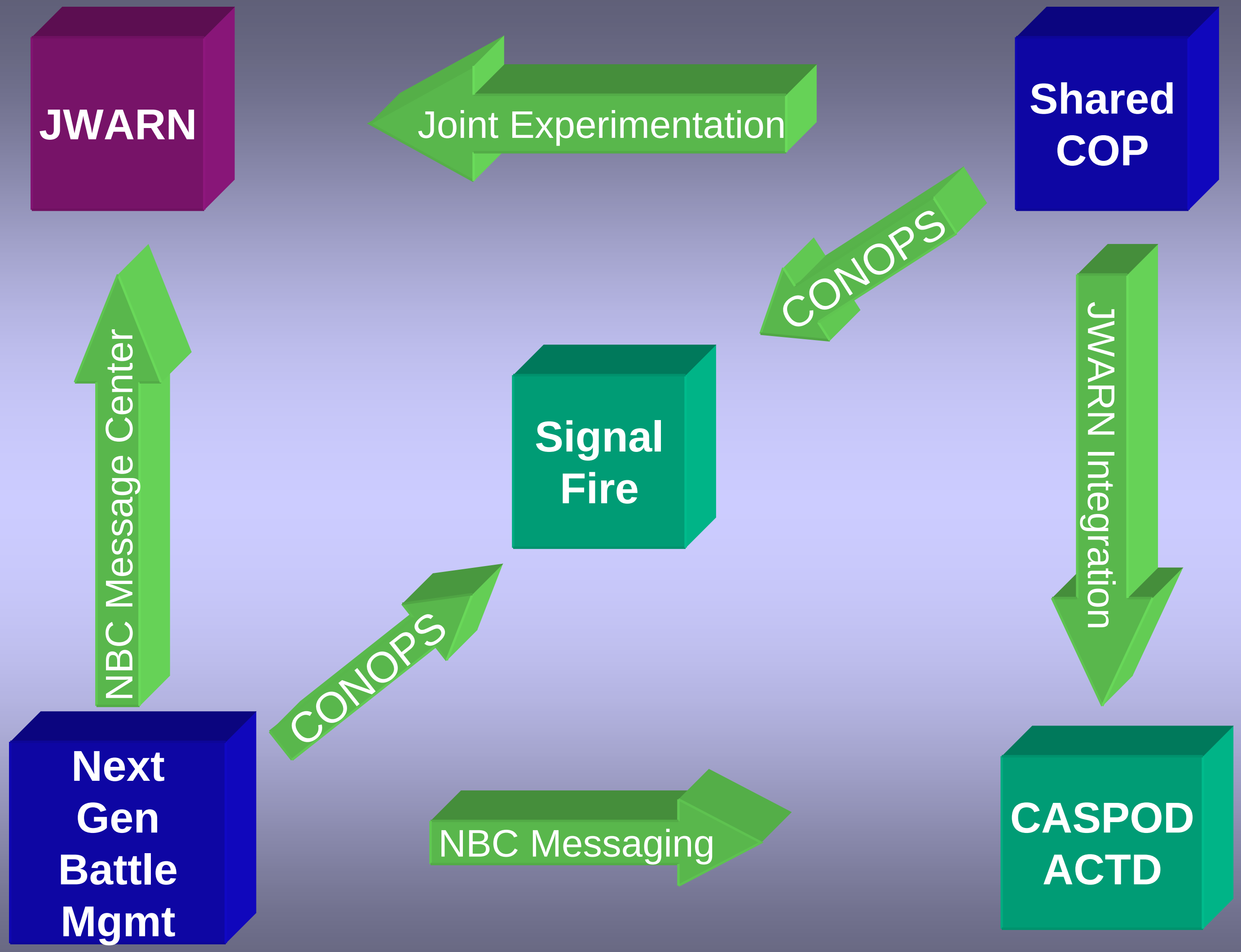
Automated Decision Support (ADS):

- **<u>B04MSB1010</u>: Next Generation CB Battle Management (6.2)**
- **<u>C05MSB0005</u>: Shared Common Operation Picture (COP) for HLS & HLD (6.3)**
- **<u>C05MSB0060</u>: Web Services, NCES, GIG Integration (6.3)**

Looking back on the year that was….

JOINT SCIENCE AND TECHNOLOGY OFFICE
MODELING AND SIMULATION
BATTLESPACE MANAGEMENT
CHEMICAL AND BIOLOGICAL DEFENSE

Leveraging and Collaboration



Principal Investigator

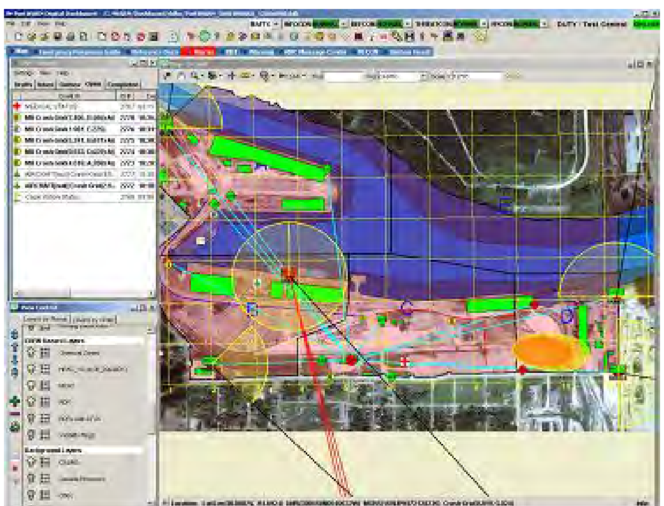
CB Defense Battlespace Management

Automated Decision Support (ADS)

B04MSB1010: Next Generation CB Battle Management (6.2)

Key Elements:

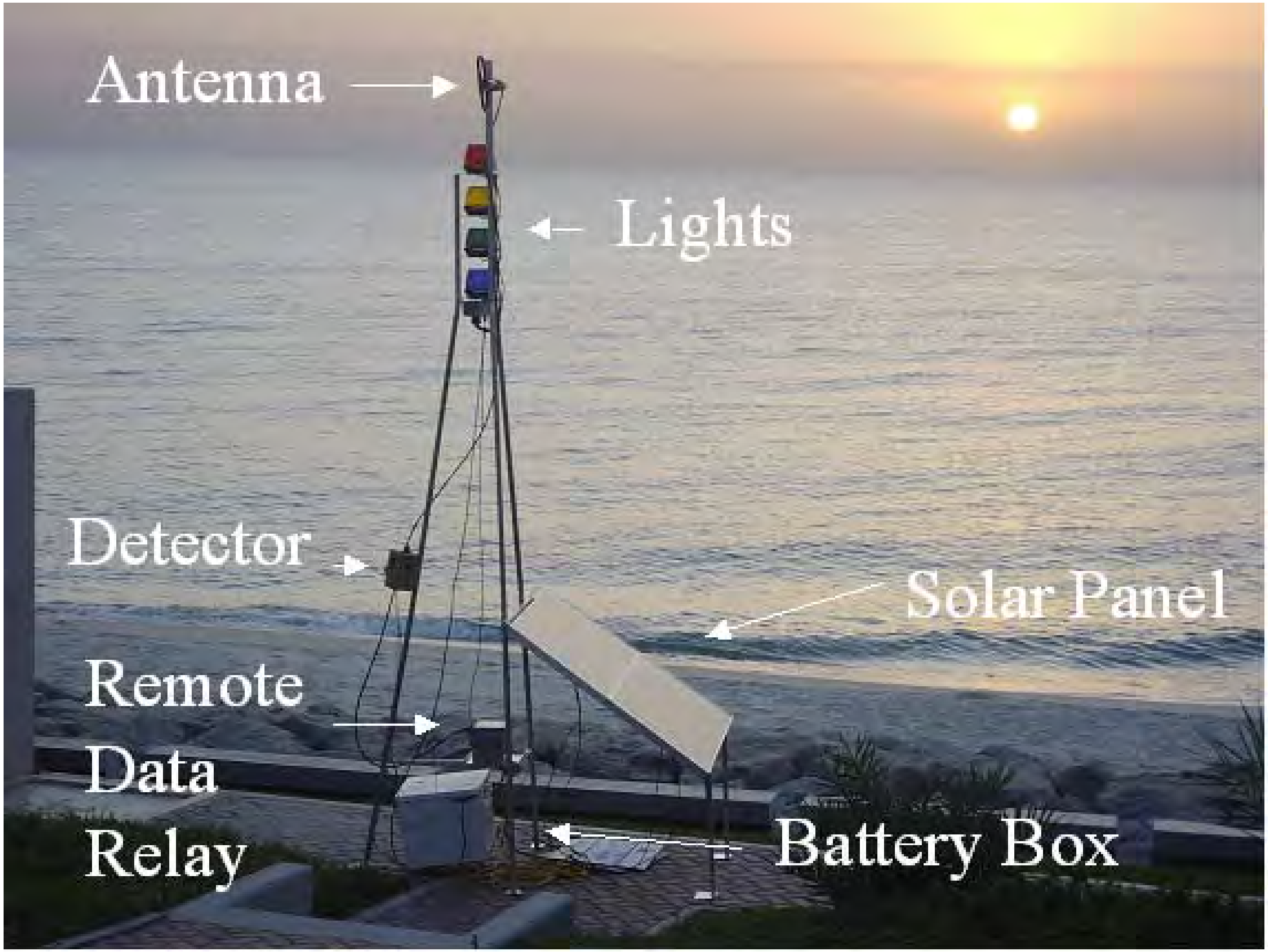
- Decision Support
- Multi-Level Networks
- Active Guidance
- Intelligent Agents
- Information Filtering



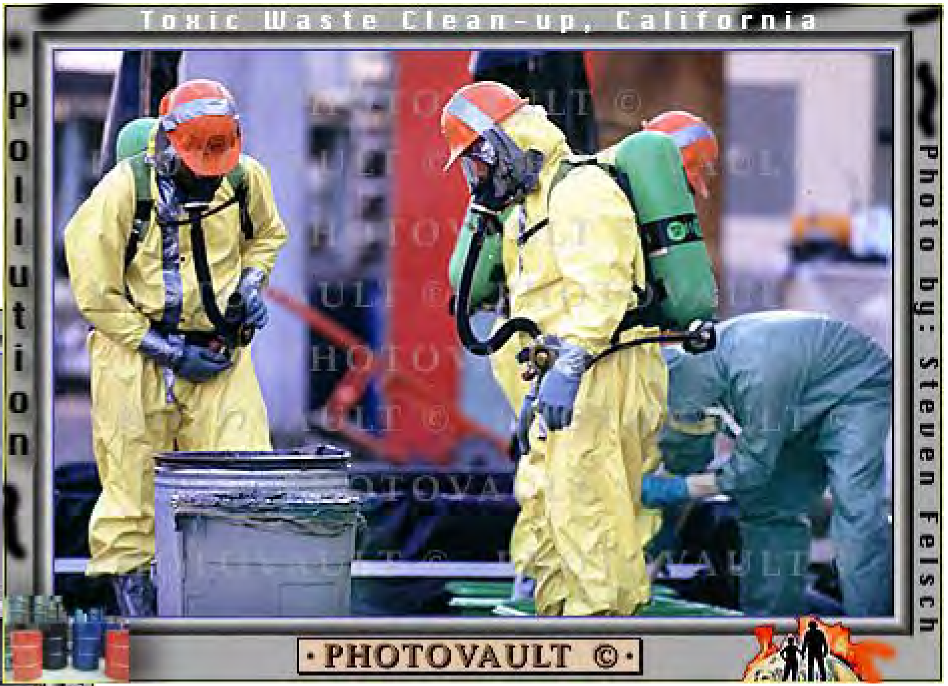
Description of Effort: Develop a configurable battle management system designed to incorporate modules for data acquisition, contamination region models, mission impact models, information sharing, information display and warning.

Next Generation CB Battle Mgmt

CASPOD ACTD Node



Battlespace Management is not just for CWA, but



TOXIC INDUSTRIAL CHEMICALS TOO!

Principal Investigator

Supporting

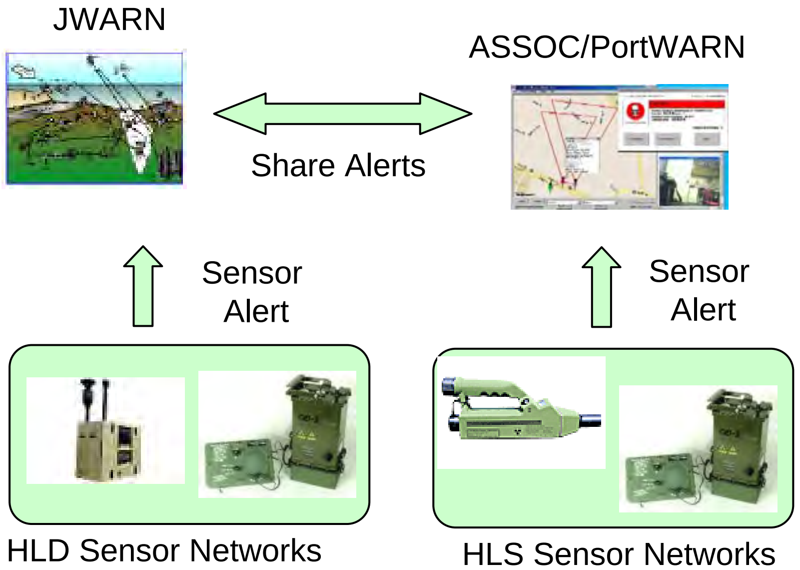
CB Defense Battlespace Management

Automated Decision Support (ADS)

C05MSB0005: Shared Common Operation Picture (COP) for HLS & HLD (6.3)

Key Elements:

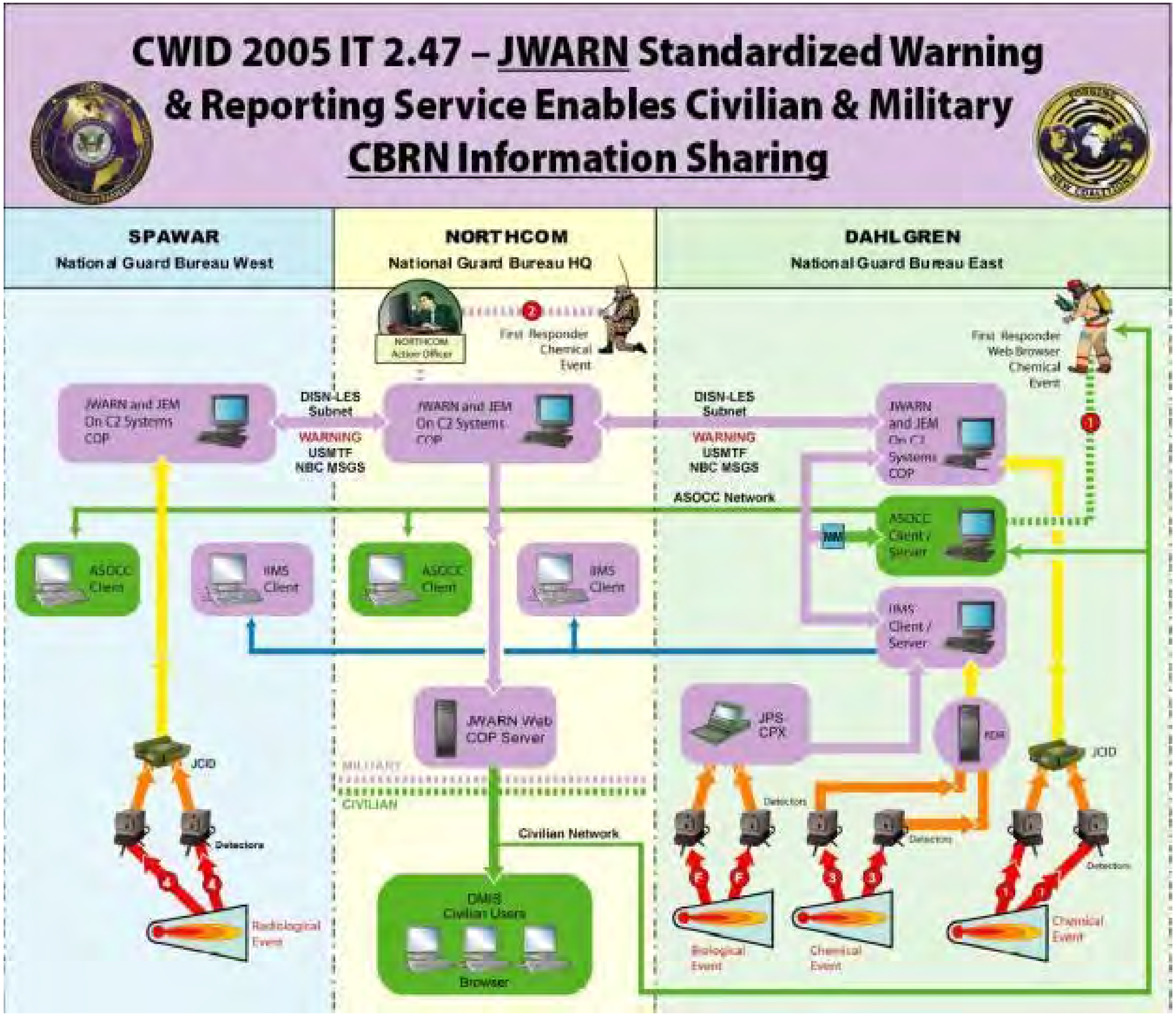
- Data Filtering
- Multi-Level Networks
- CB Data Sharing and Standardization
- CB Alerts Sharing



Description of Effort: Provide demonstrated interoperability between HLS Early Warning and Reporting targeted Systems Port Warning and Reporting Network (PortWARN) & Area Security Operations Command and Control System (ASOCC) with HLD program of record JWARN.

Shared Common Operating Picture

CWID '05



CWID 2005 IT 2.47 – JWARN Standardized Warning & Reporting Service Enables Civilian & Military CBRN Information Sharing
SPAWAR
National Guard Bureau West
NORTHCOM
National Guard Bureau HQ
DAHLGREN
National Guard Bureau East
NORTHCOM Action Officer
First Responder Chemical Event
First Responder Web Browser Chemical Event
JWARN and JEM On C2 Systems COP
DISN-LES Subnet
WARNING
USMTF
NBC MSGS
ASOCC Network
ASOCC Client
IIMS Client
ASOCC Client / Server
IIMS Client / Server
JWARN Web COP Server
JPS CPX
JCID
Detectors
MILITARY
CIVILIAN
Civilian Network
DMIS Civilian Users
Browser
Radiological Event
Biological Event
Chemical Event

FY06 Battlespace Management Data Call Topics

1. Develop the concept of **information fusion**. Information fusion includes CBRN detectors, hazard prediction, and incident management. Information fusion should feed decision support applications that are premised on active guidance. **Develop a tool that identifies patterns, trends and relationships that assist the warfare commander in development of a course of action in response to an impending threat**.
2. The Joint Warning And Reporting Network (JWARN) program is building the **JWARN Component Interface Device (JCID).** With the JCID, the number of detectors that are capable of being networked will rise significantly in the coming years. Detectors will continue to be unit assets. The operational reality is that detectors will join then leave networks as units move through areas. **Develop a program to determine the impact to contamination avoidance, hazard prediction, local situational awareness, and local CB coverage**. Ensure that it can function in an operational environment.

FY06 Battlespace Management Data Call Topics

3. The **CBRN data model** is an evolving standard being produced by the Joint Program Executive Office – Chemical/Biological Defense (JPEO-CBD). **Propose exploitation efforts of the CBRN data model** for the purposes of verification and validation of the schema against emerging CB programs.
4. Multiple runs of a hazard prediction model typically accomplish the current process of **locating detectors on the battlefield**. This process works fine in an analytical environment but is not operationally suited for field use. **Propose a sensor placement model.**

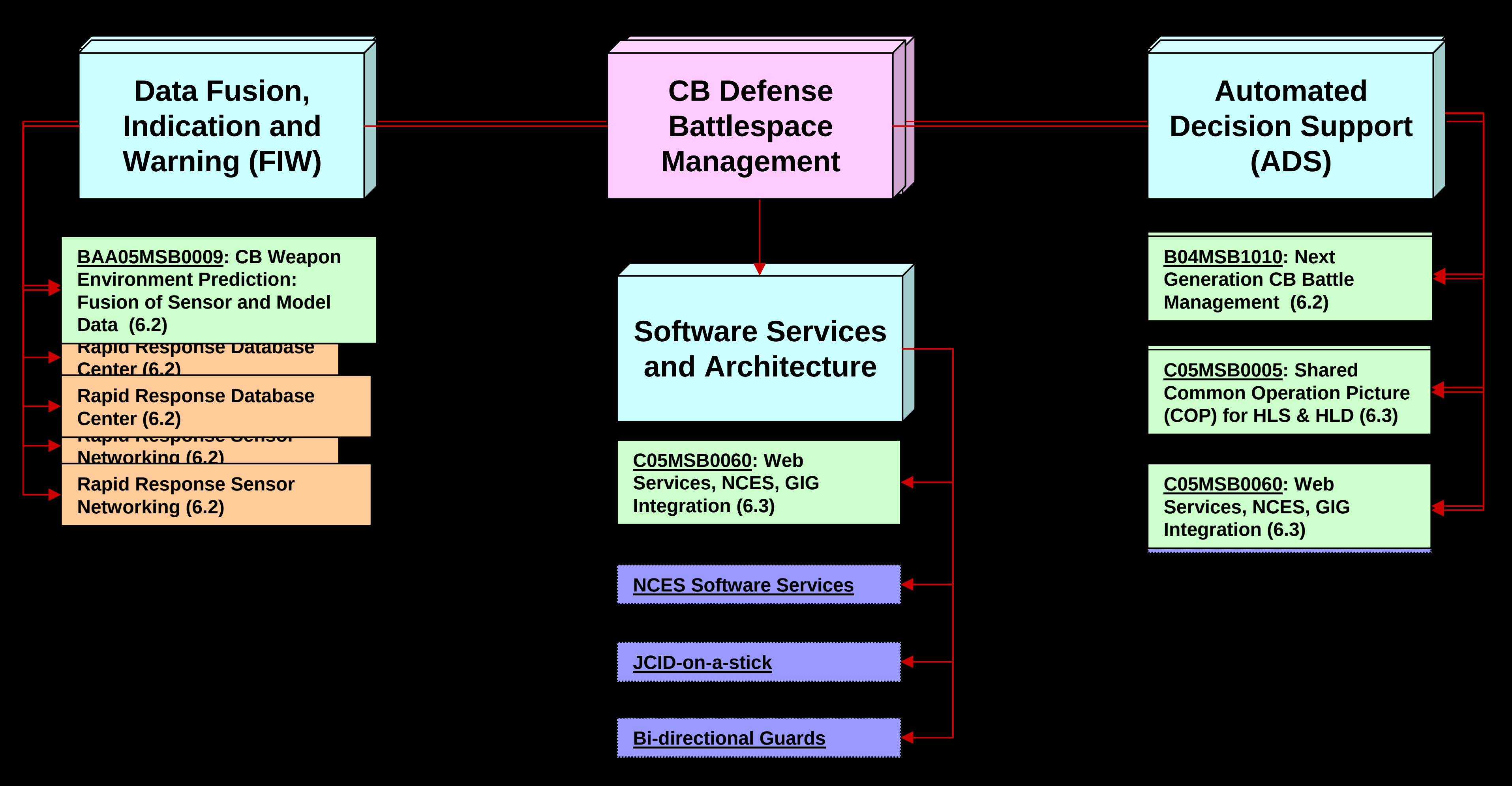
FY06 Battlespace Management Data Call Topics

5. Detector data is tactically reported over networks using commercial wireless technology or tactical radios. The ability to **move** that **data** from the **single channel domain** in which it was transmitted to **classified networks** has not been seriously addressed. **Propose an affordable method for moving sensor data to a classified network that can be certified in an operational environment.**
6. Detector locations in fixed sites typically employ a **node concept**. A node is an integration point where multiple detectors can be plugged in for the purposes economizing on force protection and power. Employing multiple detectors at a node means that the limited assets are pooled and thus leaves other areas uncovered or exposed. **Propose a concept for deploying detectors that avoids the node concept, addresses force protection concerns, and extends the coverage of the fixed site.**

FY06 Battlespace Management Data Call Topics

7. JWARN Component Interface Device **(JCID)-on-a-chip**. Field Programmable Gate-Array that has most of the features/functionality **JCID software embedded** into it and has an area that allows COI message sets (personalities/protocols) to be dynamically programmed/loaded. These could ultimately end up in Automated Chemical Agent Detector Alarms (ACADAs), etc. so that the **sensors** ultimately come **off the shelf net ready** and speaking the right data protocol/language.

Looking forward to ‘06….



FY05 Battlespace Management Program Build

Guidelines for ’06 Projects

- Develop cells within digital dashboard
- Java
- Minimal GUI development, use digital dashboard to maximum extent possible
- Technology Transition Agreements
- Data Model
- “We ♥ JEM”™
- Demonstrable progress – Align with DoD exercises where practical

Questions, Comments, Observations, Complaints, Idiosyncrasies

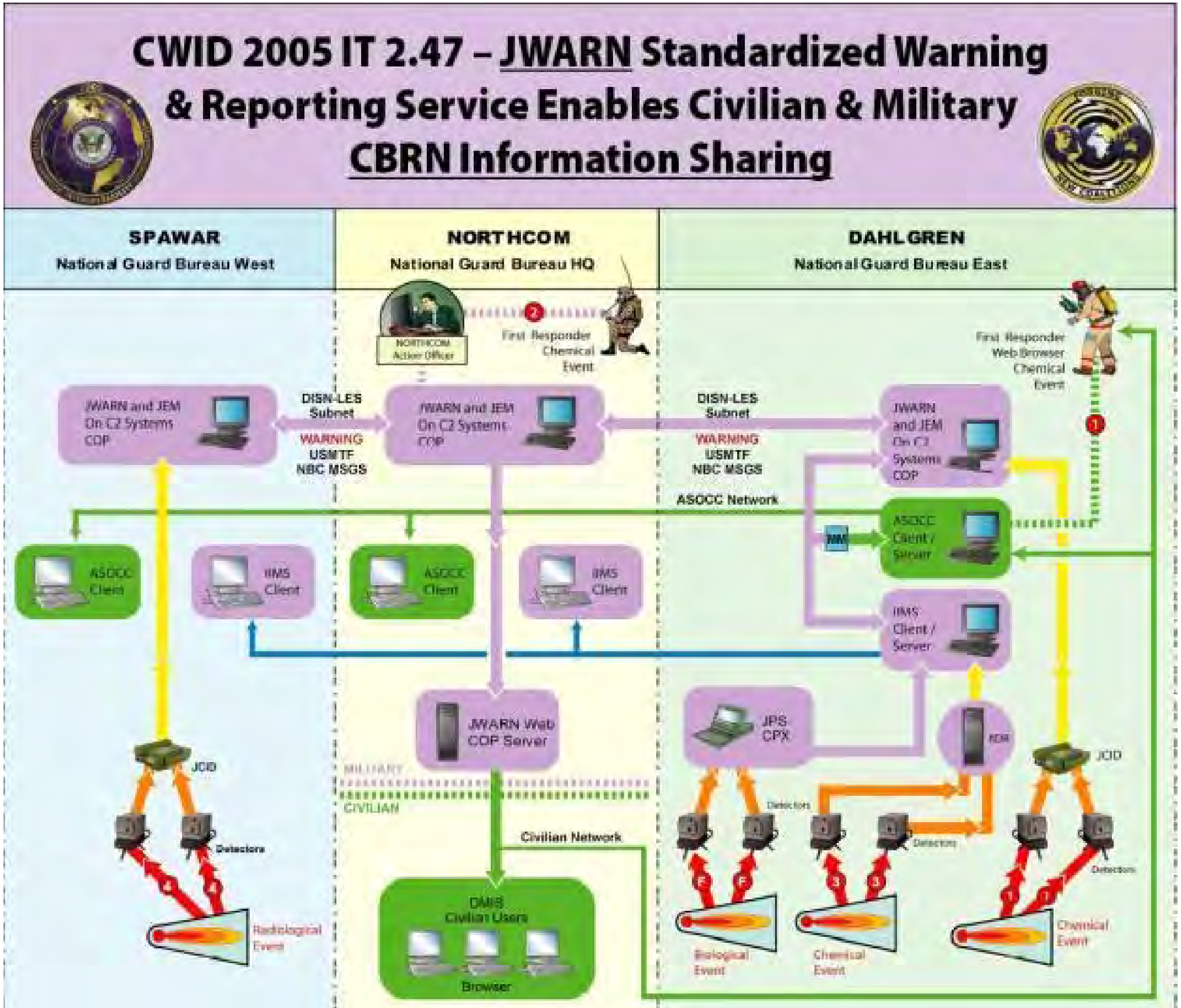
William J. Ginley
Battlespace Management Thrust Area Manager
Edgewood Chemical Biological Center
25 October 2005

Shared Common Operating Picture

First Year Focus

- Interoperability
- Determining and then providing actionable information between system for local display
- Addressing local domain issues and assessing impacts of working on a common backbone with local security policies

JWARN's Standardized Warning and Reporting Service Enables Civilian and Military CBRN Information Sharing



SPAWAR Systems Center San Diego

Supporting Details

- Active collaboration between SPAWAR, DTRA and ECBC to develop a capability that could serve as the model for interoperability demonstrations.
- Builds on S&T development of Next Generation Battle Management and the Contamination Avoidance at Seaports of Debarkation ACTD
- Provides a blue print to transition efforts from S&T to 6.4
- Trial was rated 7 of 152 by NorthCOM

Key Findings

- CAP Messages are emerging, but require further work… Required a message mediator be built to process between them. Simple middleware program to convert
- Common Message Parser very difficult to work with
- Integration points or bridges versus complete integration

Second Year Focus

- Connecting to different security levels and passing data generated by sensor networks operating on local policies and information assurance procedures
- Explore the differences of local domain issues (DHS vs DoD) and discover and solve impediments to passing data

High Level Architecture Compliance: Source Term Estimation Demo

Ian Griffiths

Andrew Solman

Ben Swindlehurst

High Level Architecture Compliance Program Aims

- Support other Dstl-JSTO tasks
  - Allow testing of components in larger simulation
  - Allowing components to be demonstrated
  - Allowing components to be exploited in experimentation events
- Focuses on one JSTO task each year
  - Year 1: Source Term Estimation (STE)
  - Year 2: Chemical and Biological Effects on Operations (Impact Assessment Tool)
  - Year 3: Fusion of Sensor and Model Predictions

Use of HLA

- High Level Architecture
  - Mechanism that enables simulations to communicate and collaborate
  - Developed by Defence Modeling and Simulation Office (DMSO)
  - Now IEEE standard (IEEE 1516)
- Used because provides framework for Modelling and Simulation interoperability
  - Could use other mechanisms

Year 1 Progress: STE Demo (1)

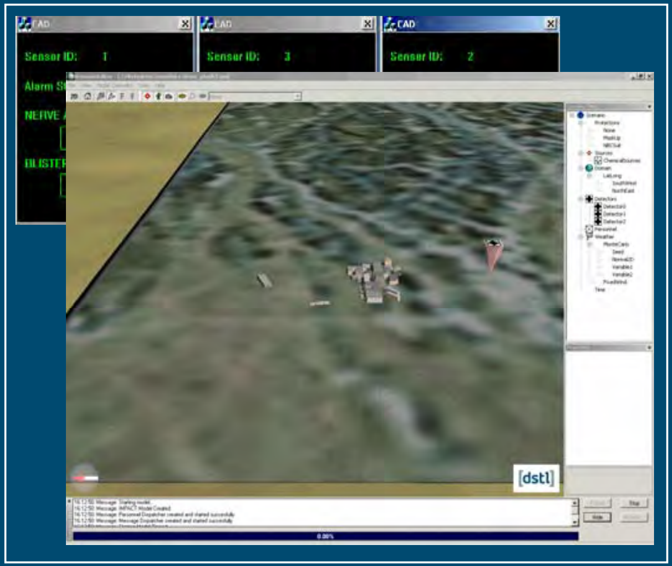
- Aim was to provide demonstration of the STE task capability
  - Allows testing within a realistic simulated world
  - Shows the role of STE in an example system
- Built upon previous M&S efforts
  - Real-time CB synthetic environment
  - Chemical Agent Detector (CAD) models
  - Prototype warning and reporting system

Year 1 Progress: STE Demo (2)

- Updated detector models providing continuous bar readings
- Integrated Source Term Estimation modules
  - Geometric STEM
  - STEM I
  - STEM II
- New or updated HLA interfaces throughout to reflect new and enhanced components

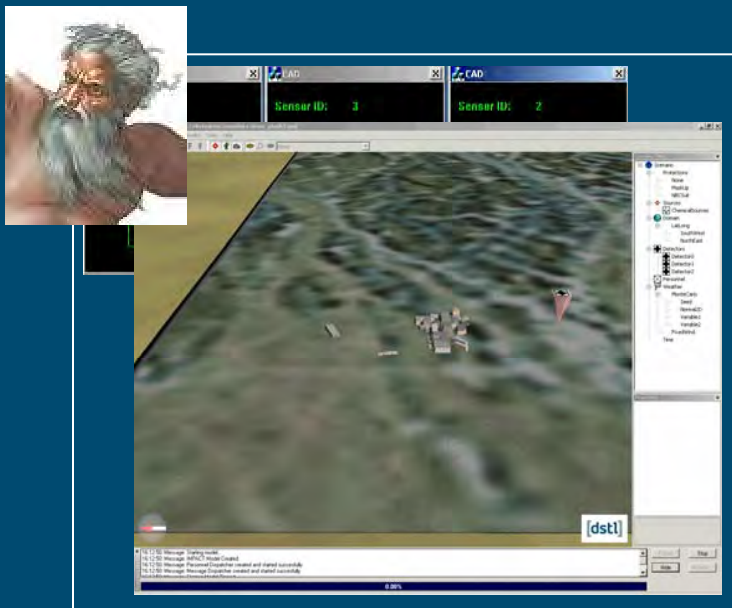
STE Demo Components

STE Demo Components



PC 1 - God's view

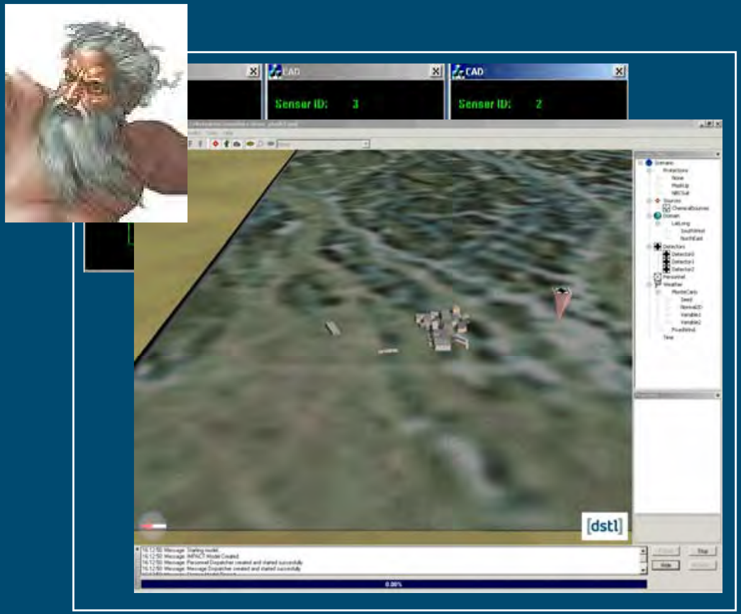
STE Demo Components



PC 1 - God's view

- Met server
- Release generator
- CBSim - Real-time CB synth. env.
- CBSim Visualiser - ground truth view
- CAD bar detectors

STE Demo Components



- CBSim provides ground truth of CB event
  - Realisation of plume dispersing in meandering wind field
  - Includes
    - FACTS wind flow model
    - MEANDER turbulence model
    - UDM puff model
    - In-cloud concentration fluctuation model

<u>PC 1 - God's view</u>

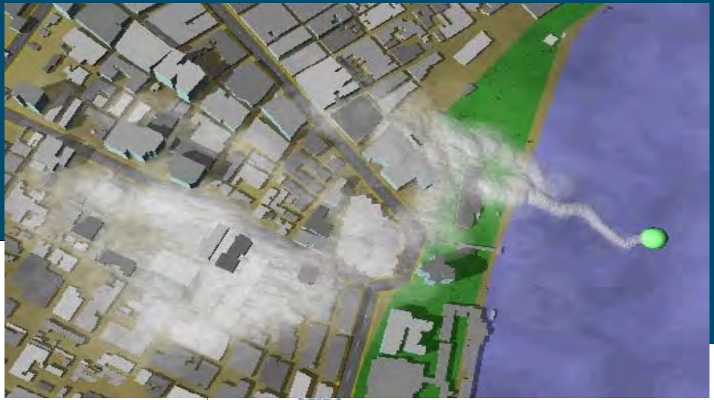
Met server

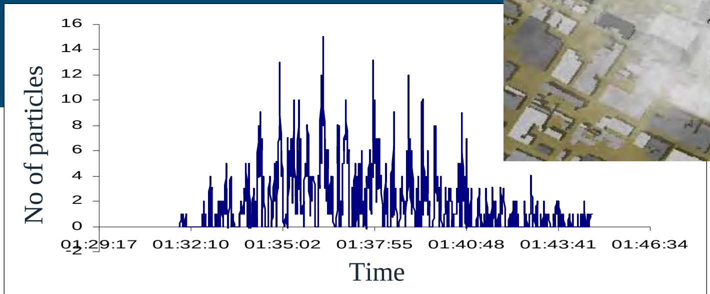
Release generator

CBSim - Real-time CB synth. env.

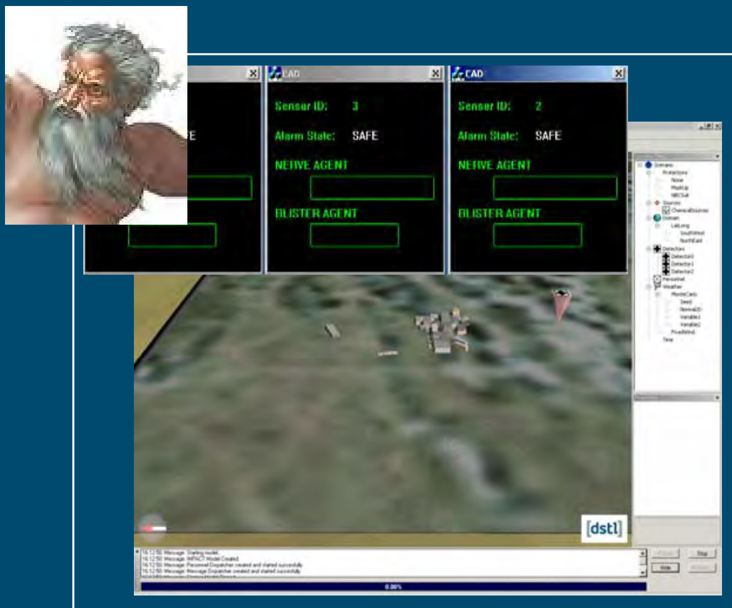
CBSim Visualiser - ground truth view

CAD bar detectors





STE Demo Components



- CBSim provides ground truth of CB event
- Stimulates chem detectors
  - Simulated detectors respond to modelled challenge

<u>PC 1 - God's view</u>

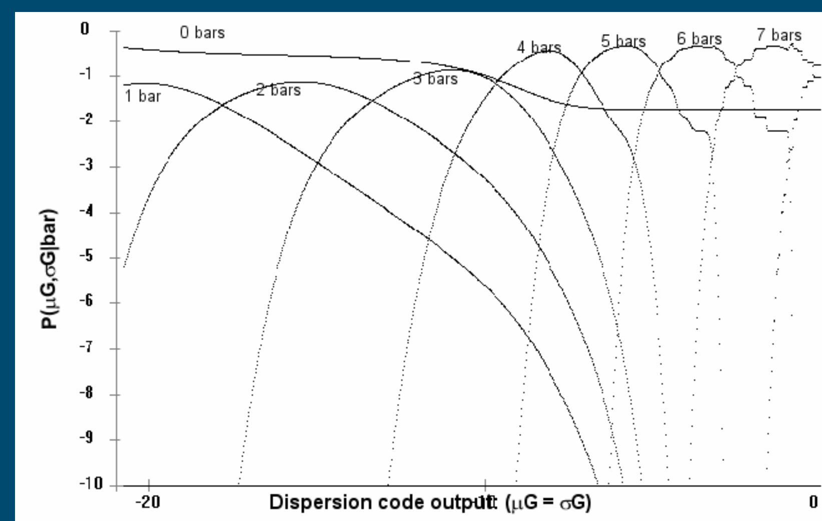
Met server

Release generator

CBSim - Real-time CB synth. env.

CBSim Visualiser - ground truth view

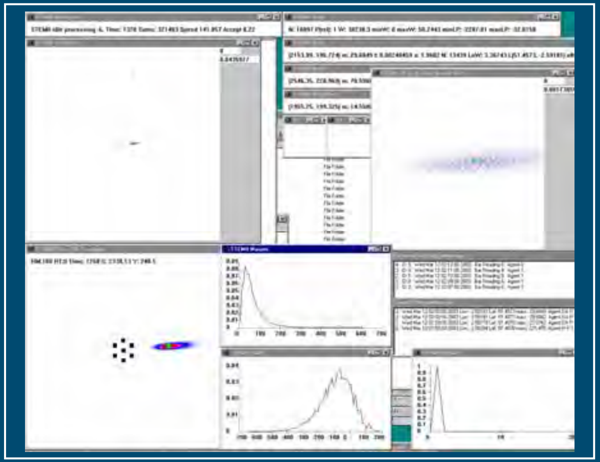
CAD bar detectors



Dstl is part of the Ministry of Defence

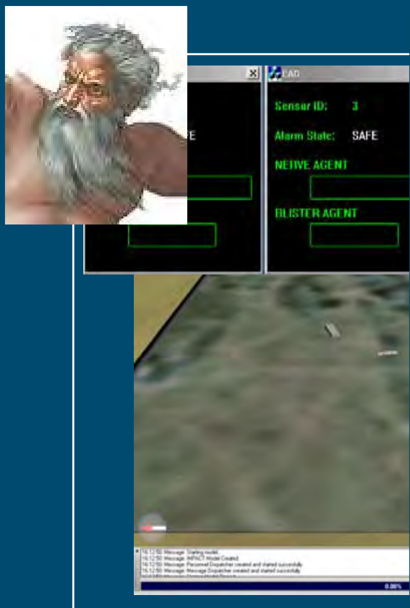
STE Demo Components

PC 1 - God’s view

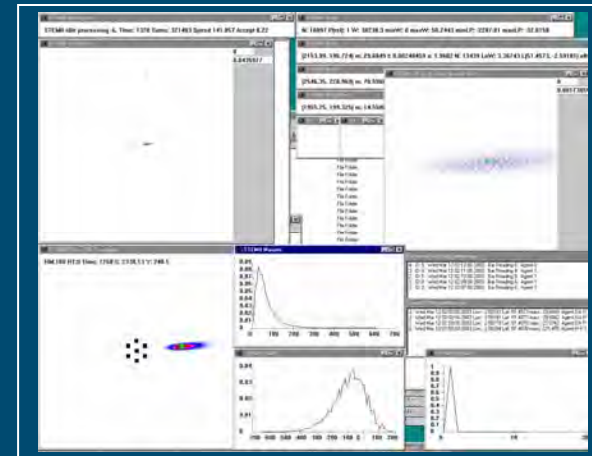


PC 2 - Boffin’s view

STE Demo Components



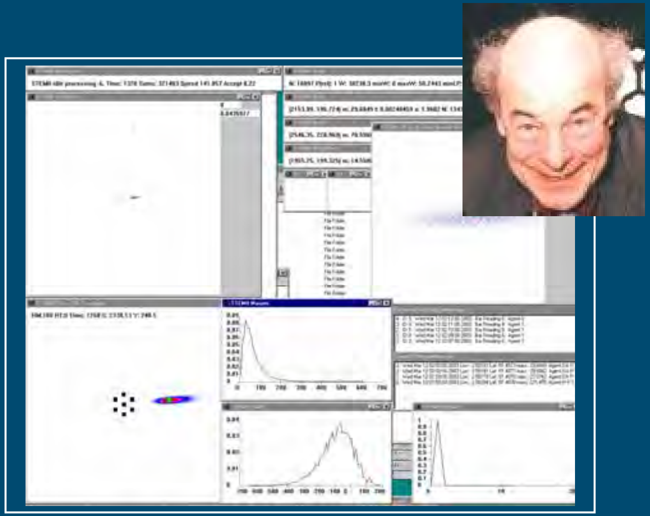
PC 1 - God's view



PC 2 - Boffin's view

STE Demo Components

PC 1 - God's view



PC 2 - Boffin's view

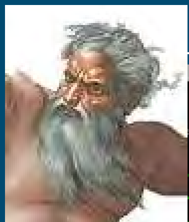
Choice of

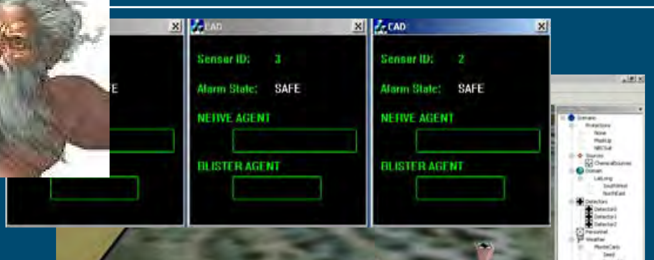
Geometric STEM

STEM I

STEM II with visualiser

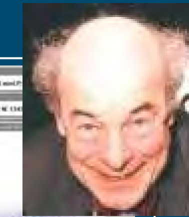
STE Demo Components

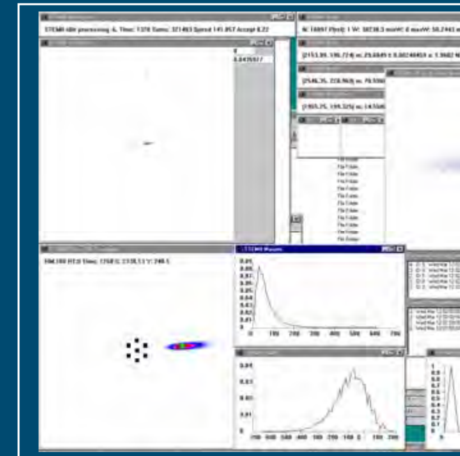




- Shows internal calculations of the inference engine
  - Hypotheses
  - PDfs for source parameters
  - Lots of other information

PC 1





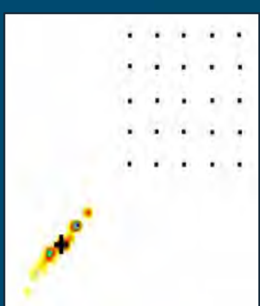
PC 2 - Boffin's view

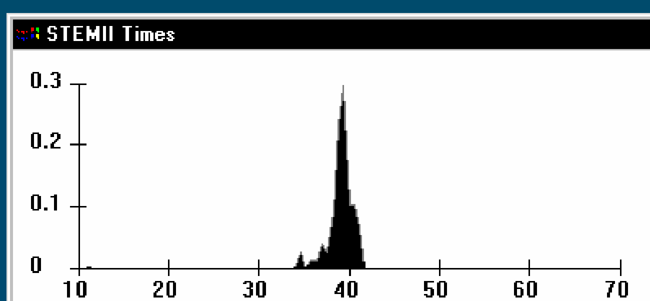
Choice of

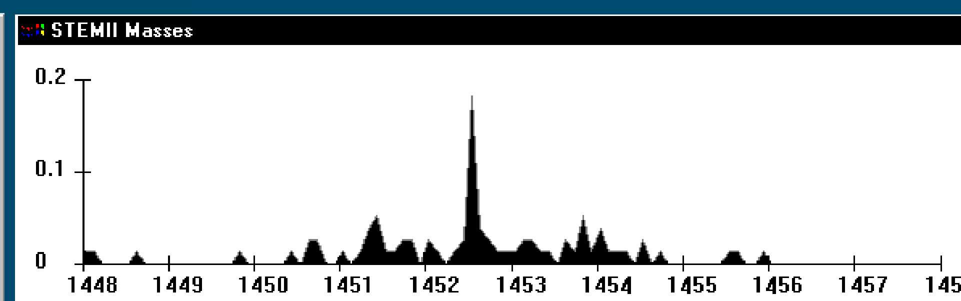
Geometric STEM

STEM I

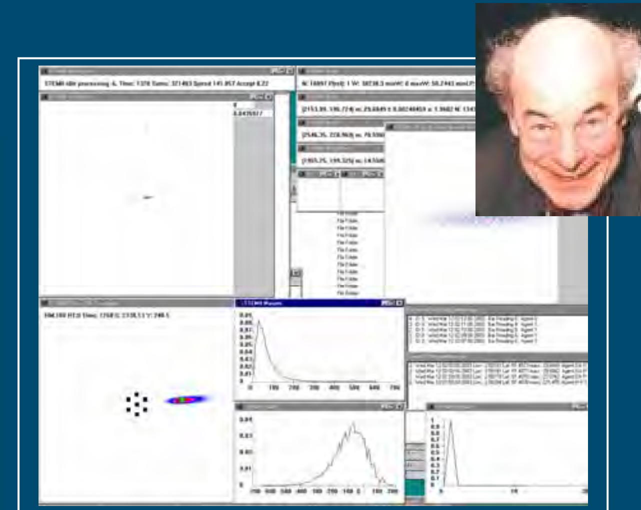
STEM II with visualiser







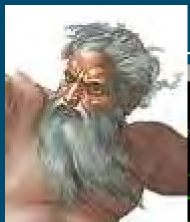
STE Demo Components



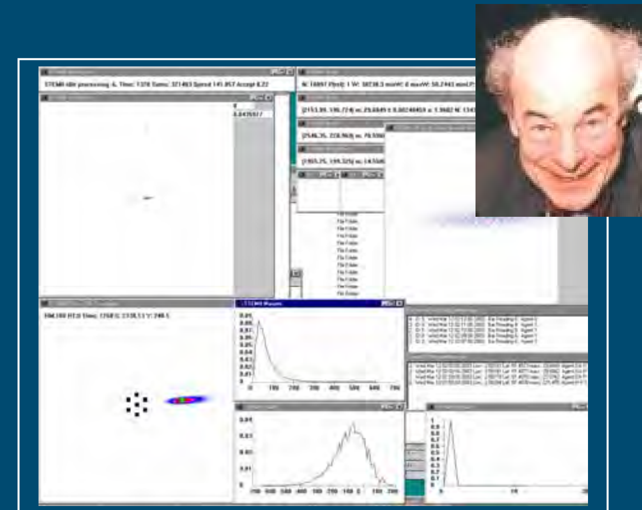
PC 2 - Boffin's view

PC 3 - Operator's view

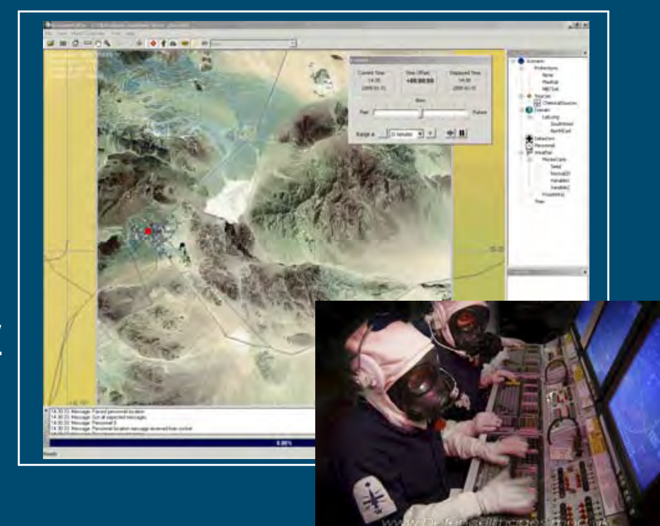
STE Demo Components



PC 1 - God's view



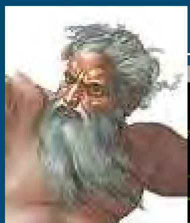
PC 2 - Boffin's view

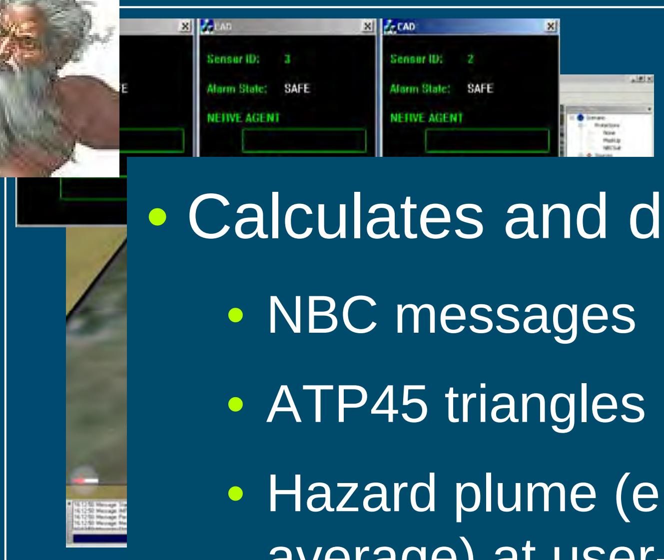


PC 3 - Operator's view

Prototype W&R system

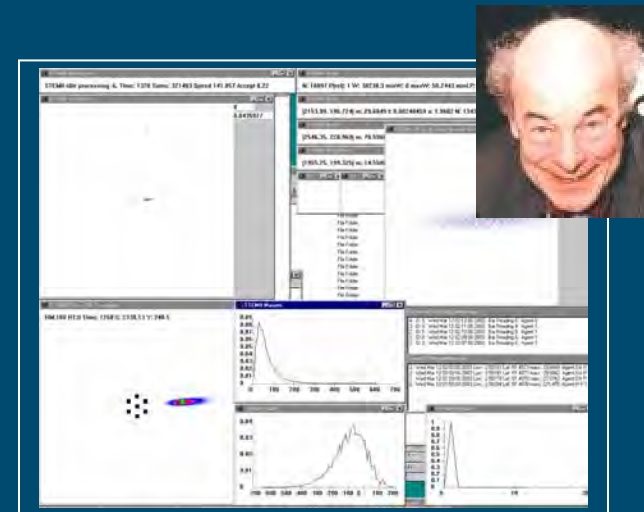
STE Demo Components



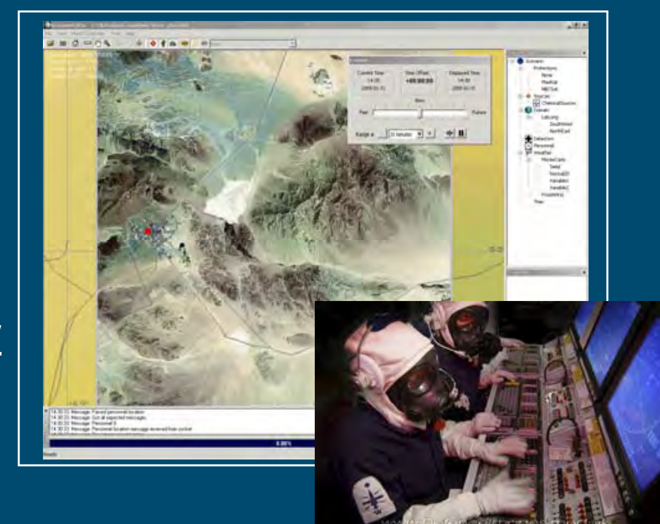


- Calculates and displays
  - NBC messages
  - ATP45 triangles
  - Hazard plume (ensemble average) at user-specified times
  - Units at risk

PC 1 - G



PC 2 - Boffin's view



PC 3 - Operator's view

Prototype W&R system

31 October 2005

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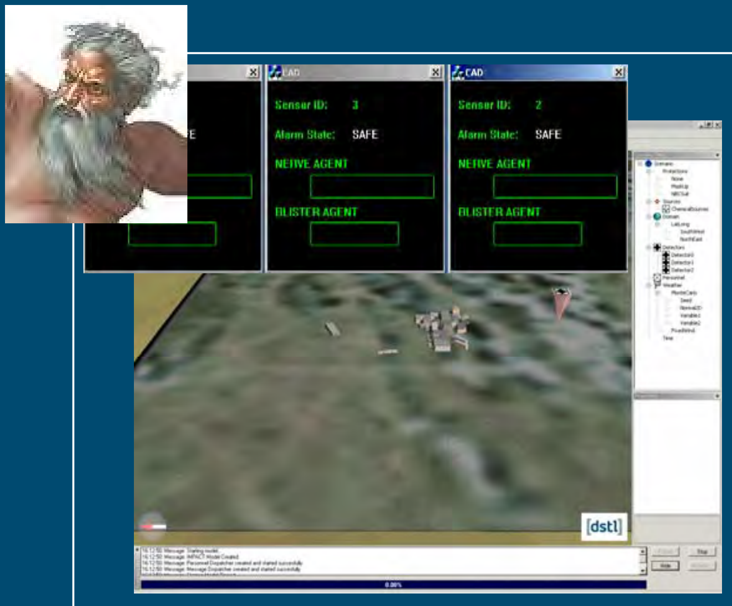
STE Demo Components



PC 1 - God's view

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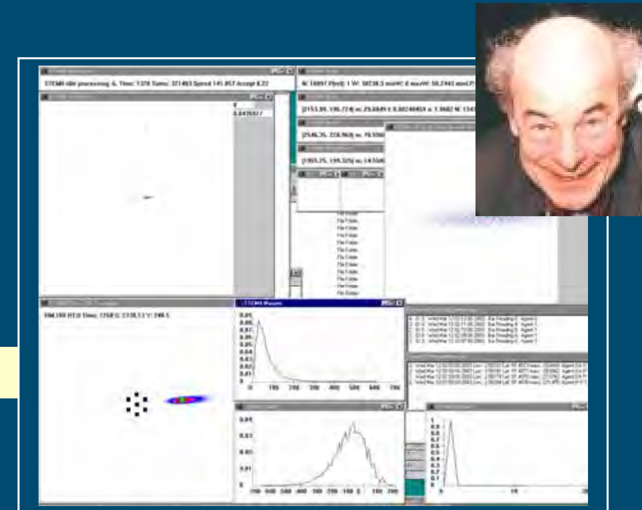
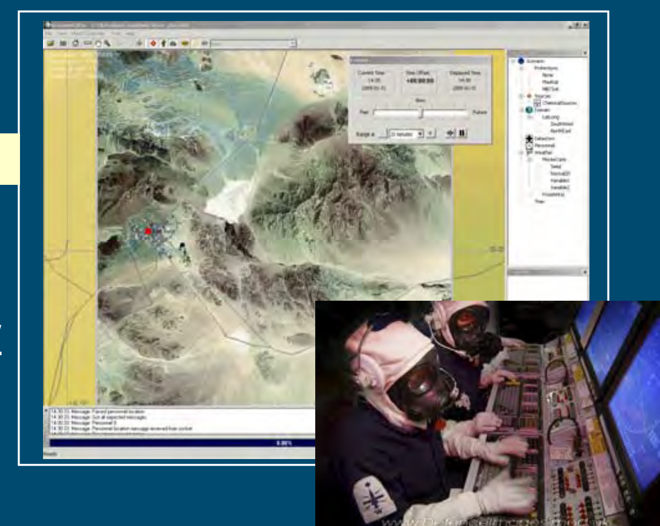


PC 2 - Boffin's view



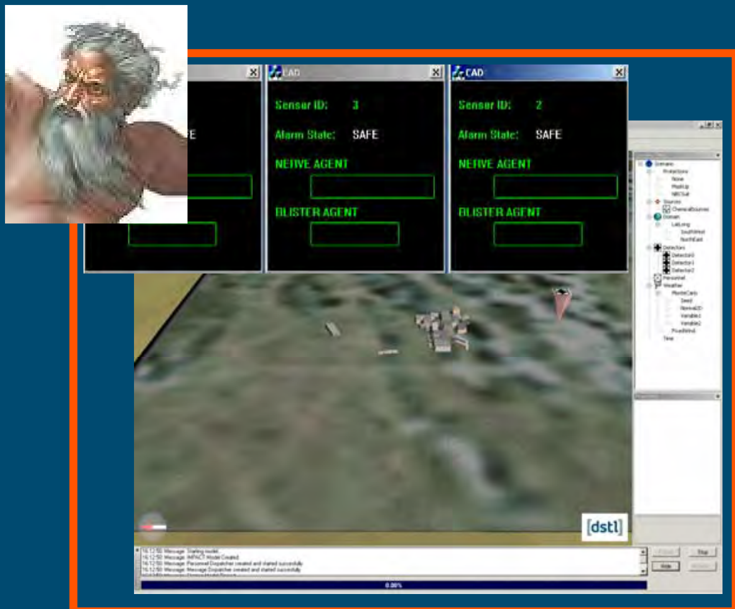
PC 3 - Operator's view

Summary

- Source Term Estimation Demo
  - Shows the source term estimation capability operating in a realistic environment
    - Works in real time
    - Provides a rigorous test environment
  - Could link to other systems, including
    - Real met feeds
    - Actual detectors
    - COP applications
- Future years of HLA Compliance work prgramme will target for support further JSTO programmes

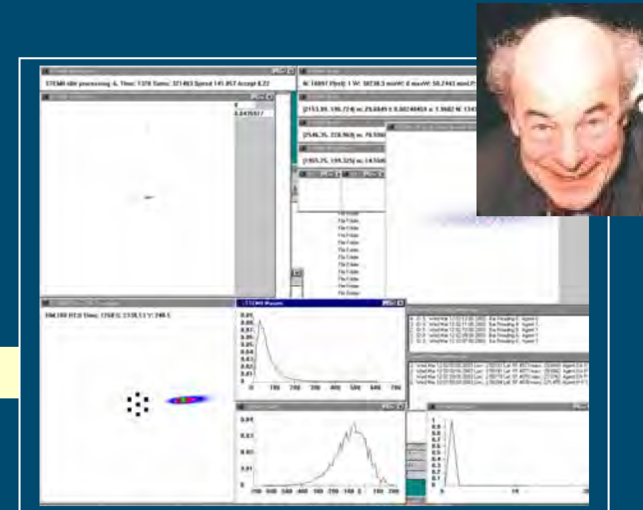
Now the demo...

STE Demo Explanation

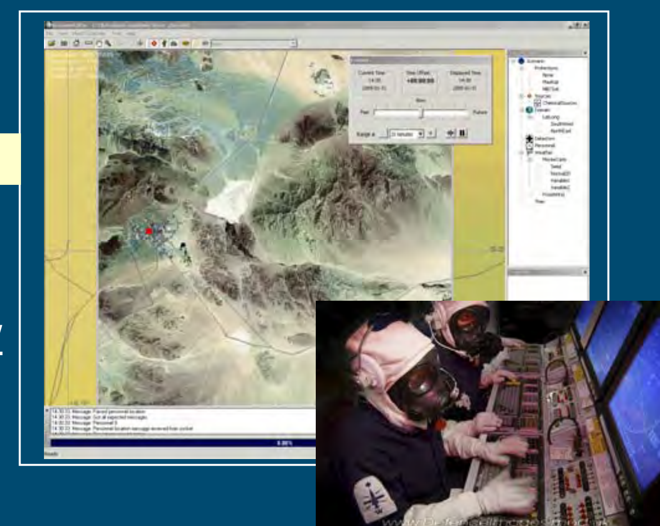


PC 1 - God's view

HLA RTI



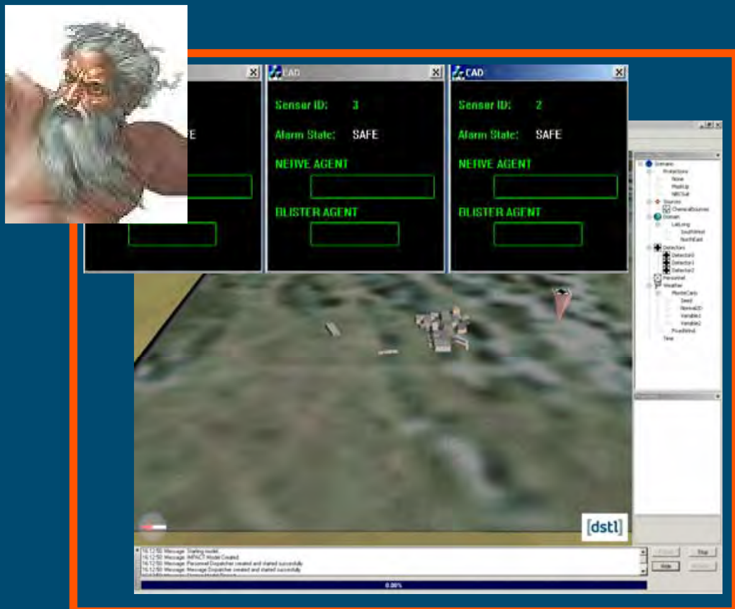
PC 2 - Boffin's view



PC 3 - Operator's view

1. Release will be added to scenario

STE Demo Explanation



PC 1 - God's view

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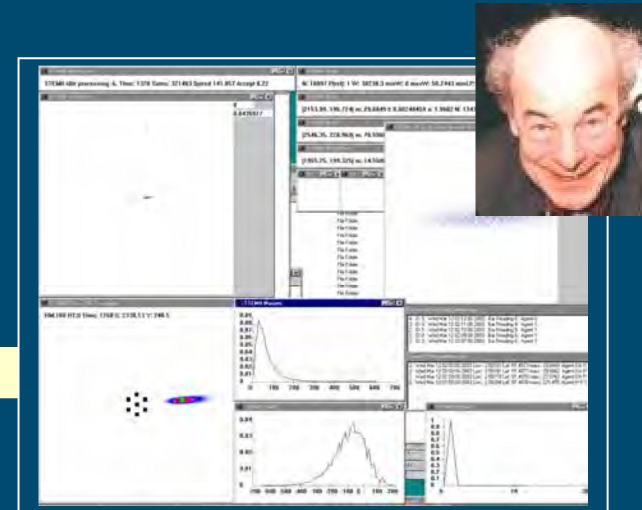
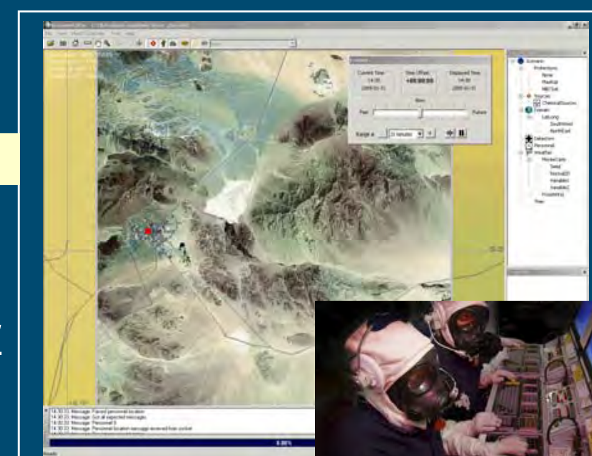
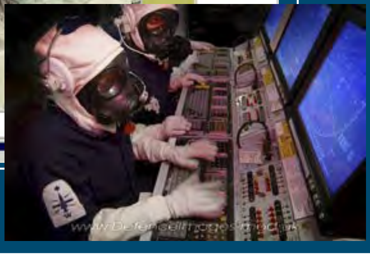


PC 2 - Boffin's view

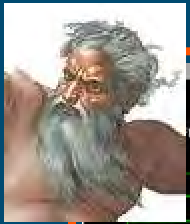




PC 3 - Operator's view

2. CBSim will model dispersion as a specific realisation

STE Demo Explanation



PC 1 - God's view

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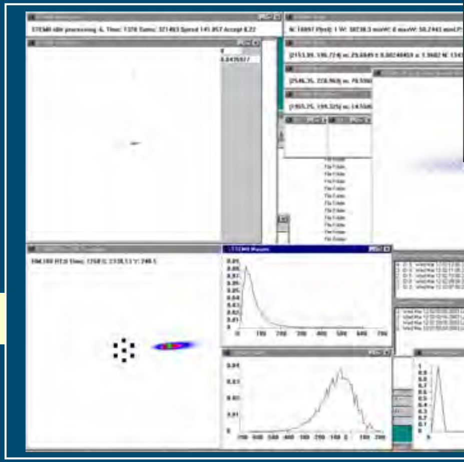
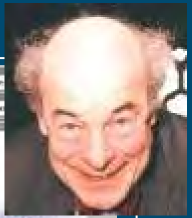
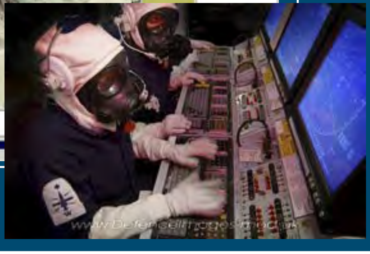




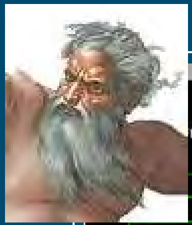
PC 2 - Boffin's view



PC 3 - Operator's view

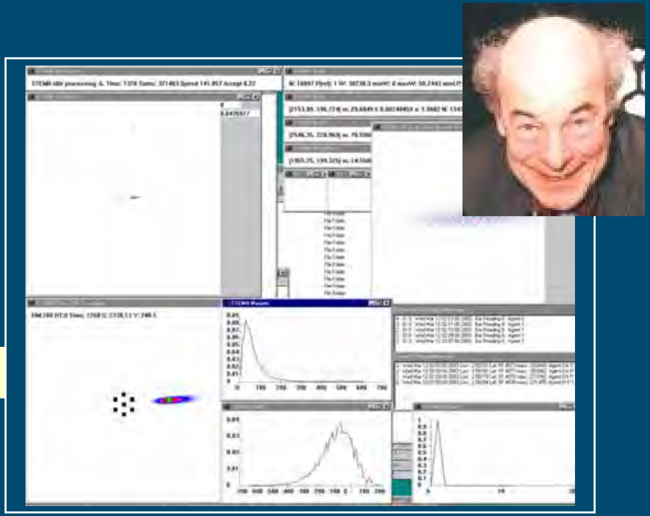
3. Cloud will hit detectors, which will alarm; an NBC message will be sent

STE Demo Explanation

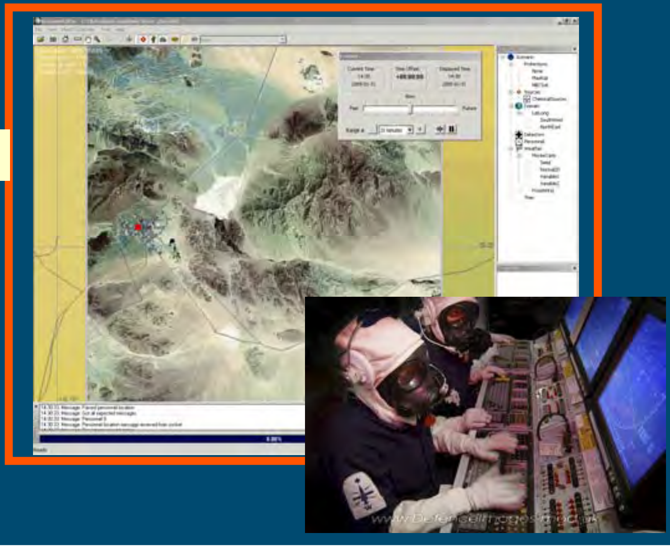


PC 1 - God's view

HLA RTI



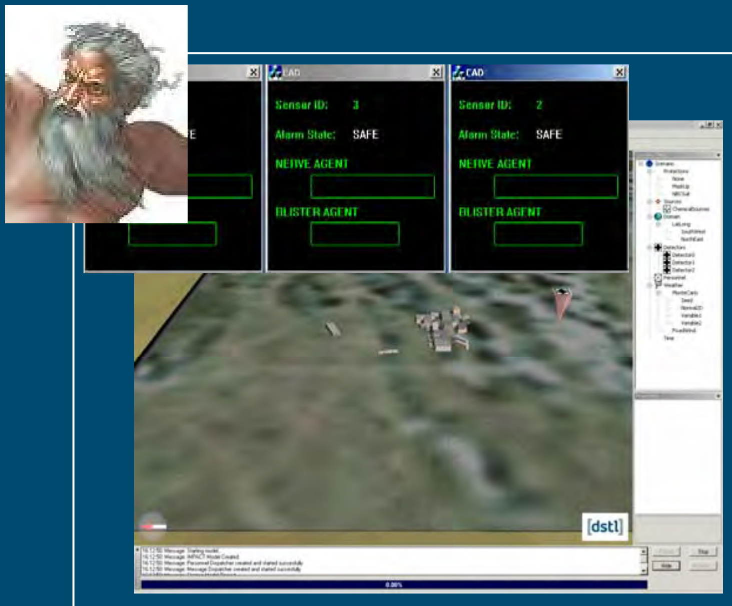
PC 2 - Boffin's view



PC 3 - Operator's view

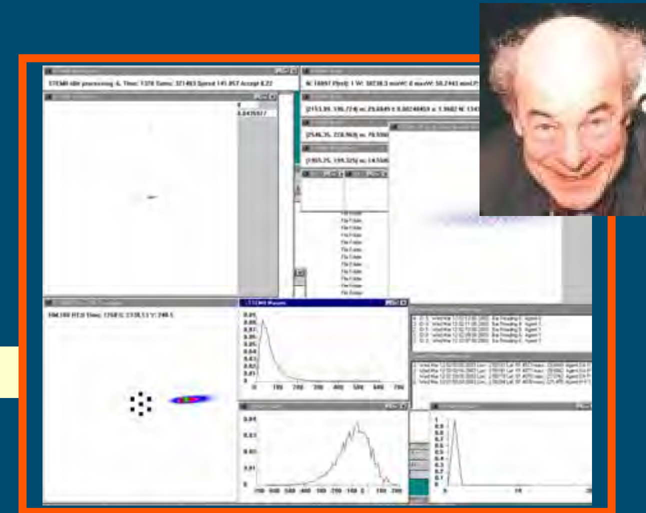
4. W&R system will display detector alarm

STE Demo Explanation

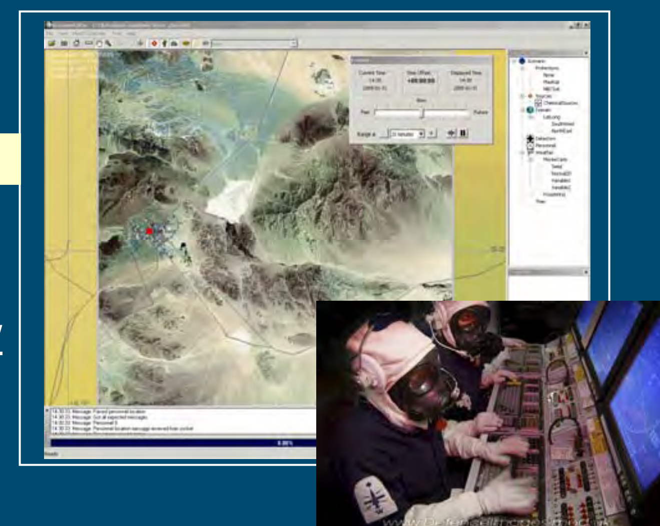


PC 1 - God's view

HLA RTI



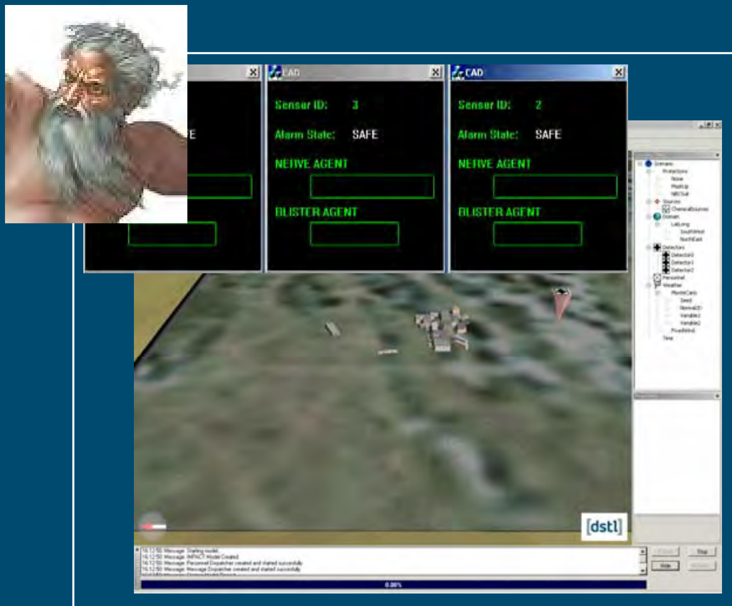
PC 2 - Boffin's view



PC 3 - Operator's view

5. STEM II will fuse continuous output of detectors

STE Demo Explanation



PC 1 - God's view

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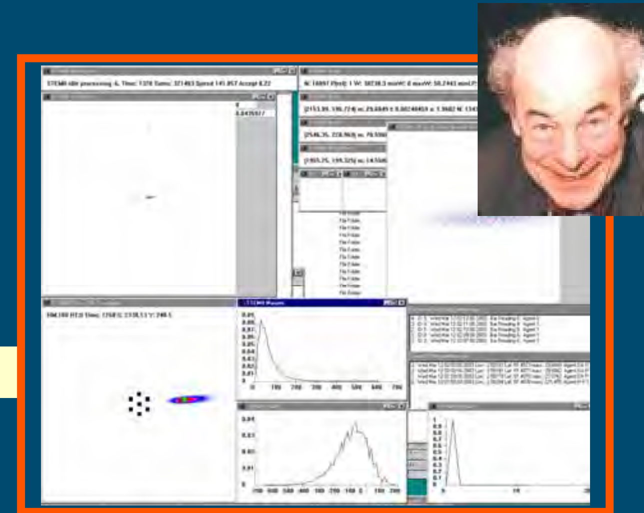
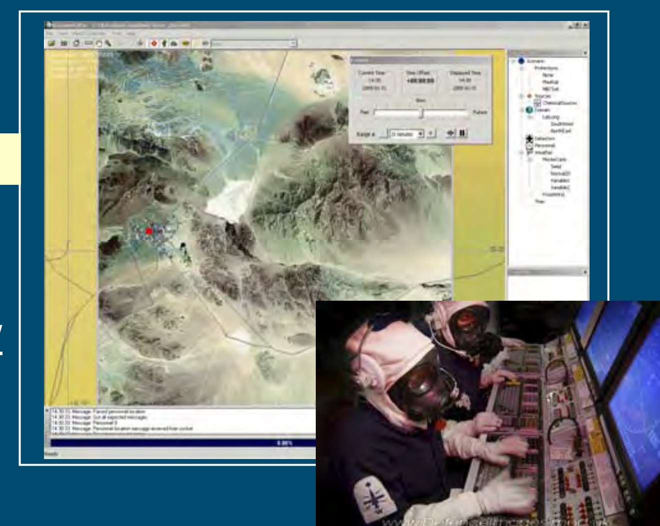


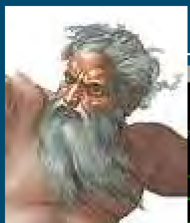
PC 2 - Boffin's view



PC 3 - Operator's view

6. STEM II will transmit most likely source term as an NBC message

STE Demo Explanation



PC 1 - God's view

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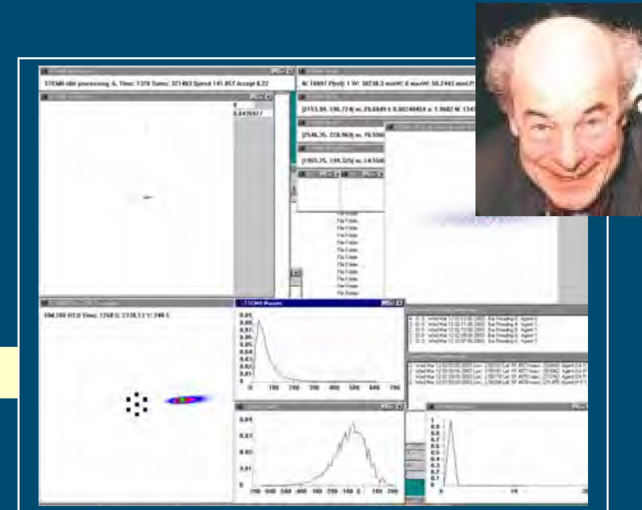
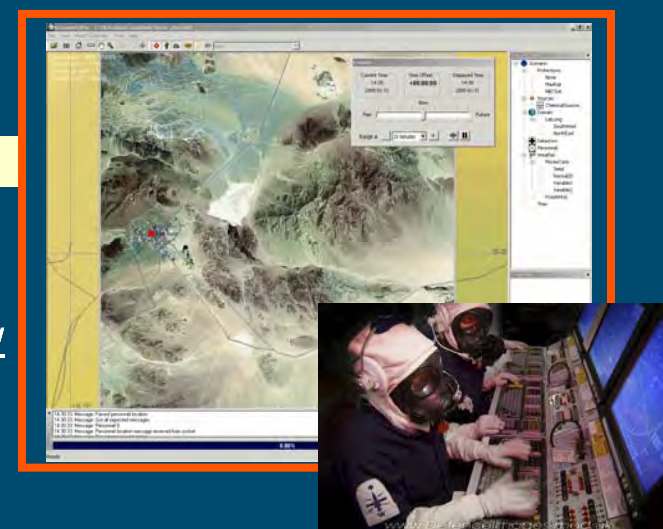


PC 2 - Boffin's view



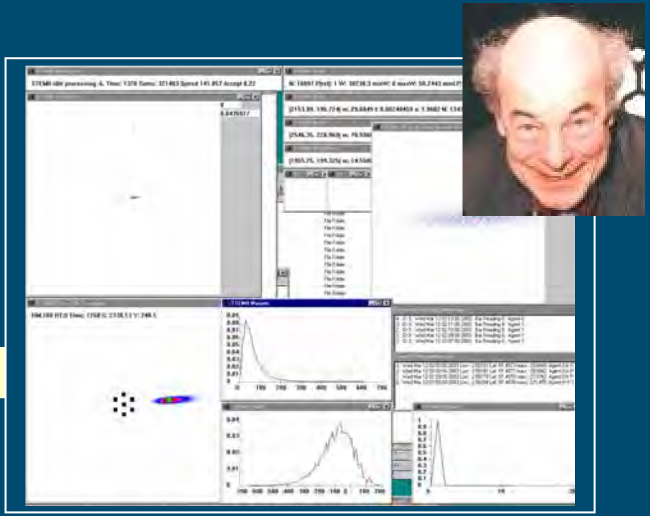
PC 3 - Operator's view

7. W&R system will display predicted source location and ATP45 triangle

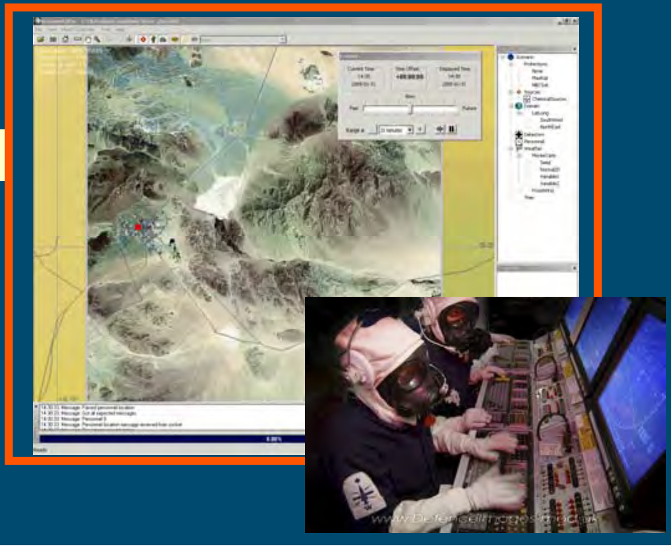
STE Demo Explanation

PC 1 - God's view

H L A R T I



PC 2 - Boffin's view



PC 3 - Operator's view

8. W&R system will model and allow display of predicted hazard plume

Analytical Capabilities Development

Institute for Defense Analyses

October 2005

Outline

- Overview of Task Order
- Approach
- Programmatics
- Activities to date
- Roadmap Hypotheses
- Some Recurring Questions
- CBRN Info Wargame

Overview of Task Order

- Background: Last year's look at virtual prototyping revealed a number of M&S requirements that were not being aggressively pursued because they were collected under the rubric of "virtual prototyping system"
- Objective: Assist in the development of analytical capabilities to support the JSTO IS
  - System technical performance
  - CONOPS Development
  - Cost/Effectiveness Tradeoffs
  - Military Utility

Subtasks

- Reviews & Support when asked:
  - CBIAC Library,
  - University Strategic Partnership,
  - AFRL Maneuver Unit Modeling,
  - Proposal evaluation
- M&S Capability Roadmap
- Proposal for CBRN Information Wargame

Approach

- Interviews with key stakeholders: Services, COCOMS, JRO, JWC, DPG, Chem School, JPMIS
- Review requirements documents, FNA, FSA etc.
- Examination of M&S Programs of Record
- Review of M&S investment process
- Apply long-term experience as M&S users

Activities to Date

- Documentation collection and review, including:
  - JCIDS Products FAA, FNA, FSA, JWSTP
  - JEM/JOEF/JWARN Documentation
  - CBRN Data Model
  - CBRND Implementation Plan
  - M&S OIPT Products
- JSTO MS prioritization/selection panel
- Site Visits:
  - DATSD-CBD
  - Cubic for JOEF Prototype
  - JPMIS
    - JEM
    - JOEF
  - JRO
  - UNM
  - DPG
  - WME Battle Lab/CAPT Huffman (DTRA)
  - DMSO/COL Glasow
  - Alion for CBRN Data Model

Roadmap Hypotheses

- Transport and diffusion modeling has progressed to satisfactory level of performance
- Doctrine, training and requirements will require future IT tools
- Investment in training and education tools has a long term high rate of return for the force and the program
- M&S solutions and their requirements not as well understood as boots and gloves, but the concept of military value added should be the same
- M&S can augment physical testing, but cannot replace it

Recurring questions

- How to define the utility of an M&S product, and its defining requirements?
- What metric should be used to identify the solution that is "good enough?"
- How to evaluate competing solutions when there is no unique right answer?
- How to quickly identify M&S requirements for which no feasible technology solution exists so that alternate approaches can be sought?

CBRN Info Wargame(s)

- Purpose: Examine, ID and prioritize IS/IT contributions to military operations, combat and civil support
  - Demonstrate the utility of current and planned products
  - ID possible future requirements
  - Provide a basis or insight for prioritizing IT S and T
- Levels
  - Strategic
  - Operational
  - Tactical
- Design TBD
  - Major challenge to design game to show IT effect on operations
- Resource requirements
  - Significant cost
  - MOST IMPORTANT - NEED APPROPRIATE UNIFORMED PLAYERS
- Coordination
  - JSTO-JRO-JPEO-Services, COCOMS etc

Chemical, Biological, Radiological, and Nuclear (CBRN) and Medical Communities of Interest (COI) Information Sharing

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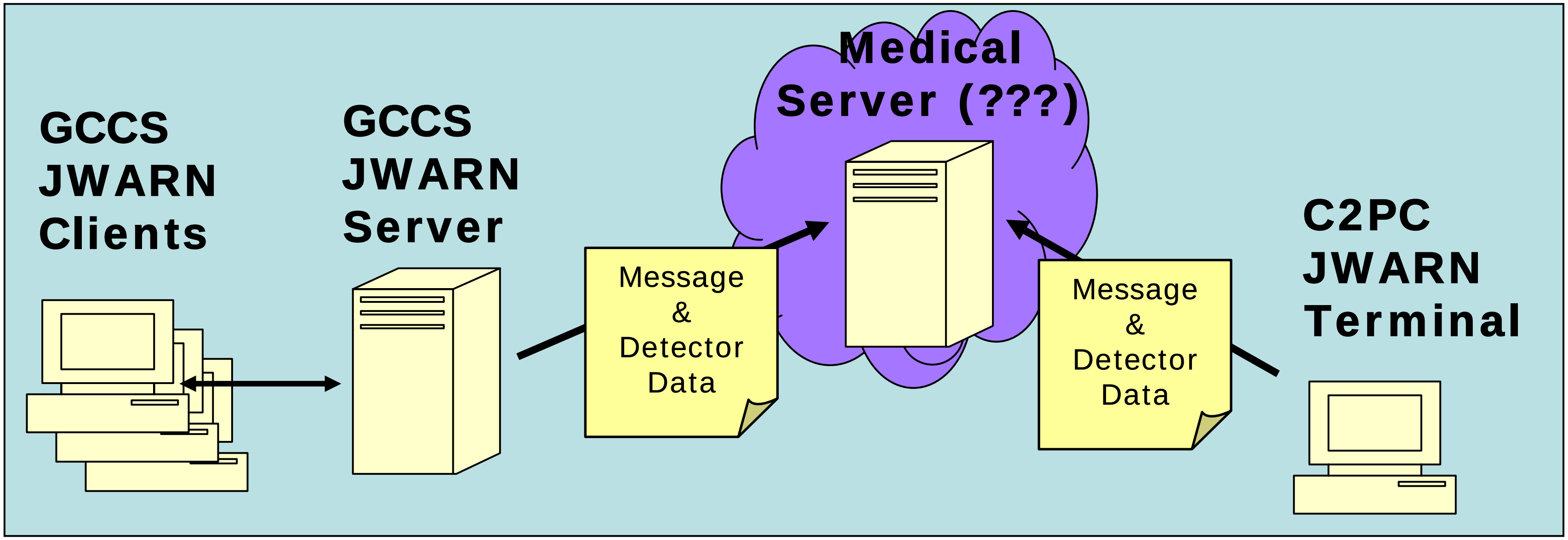
CBRN COI ⇔ Medical COI Data Sharing
(Why a Pilot?)

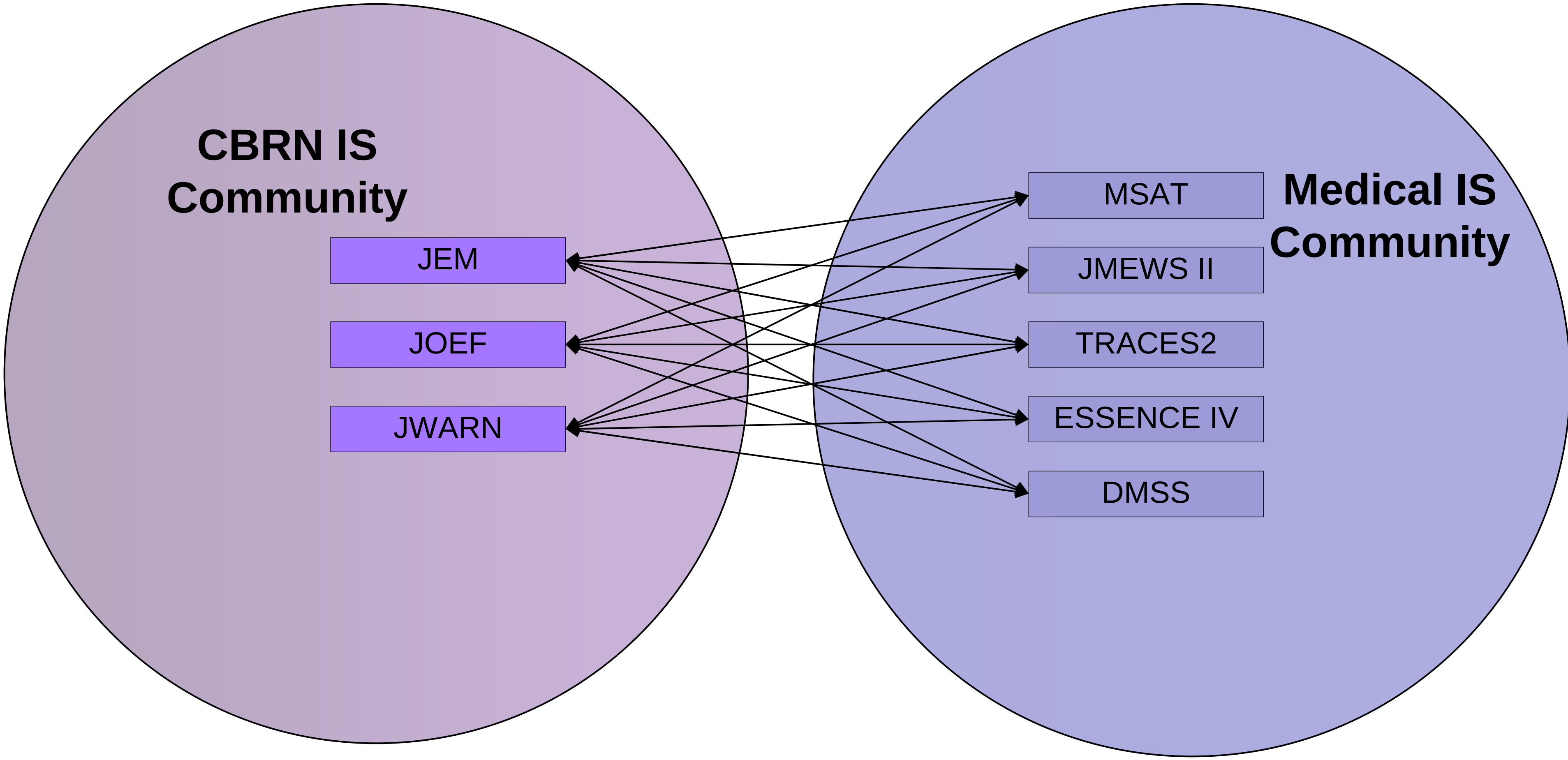
- CBRN COI to Medical COI data sharing supersedes the requirement for multiple point to point interfaces among the many separate medical and CBRN systems. Opens way for additional COI data sharing.
- No CONOPS exist for CBRN ⇔ Medical data sharing, developing notional Use Cases to facilitate CONOPS development, and promote net-centric services (DoD Net Centric Data Strategy & Web Services)
- CBRN Medical Pilot proposal suggests partnering with MSAT ACTD to enhance connectivity of both the Medical and CBRN COIs to interface/interoperate.
- The MSAT ACTD and CBRN PORs would both benefit from data sharing…
  - Pilot promotes CBRN Information Systems (IS) programs of record to:
    - pull medical data to generate CBRN course of action
    - pull medical data to CBRN to conduct crisis and deliberate planning
    - receive medical alerts and display in the CBRN view
  - Pilot promotes MSAT ACTD to:
    - pull CBRN detector/sensor data for medical surveillance
    - pull CBRN hazard prediction data for medical crisis planning/action and analysis
    - push medical alerts to the CBRN view
    - identify medical server

Notional JWARN Data Sharing Approach



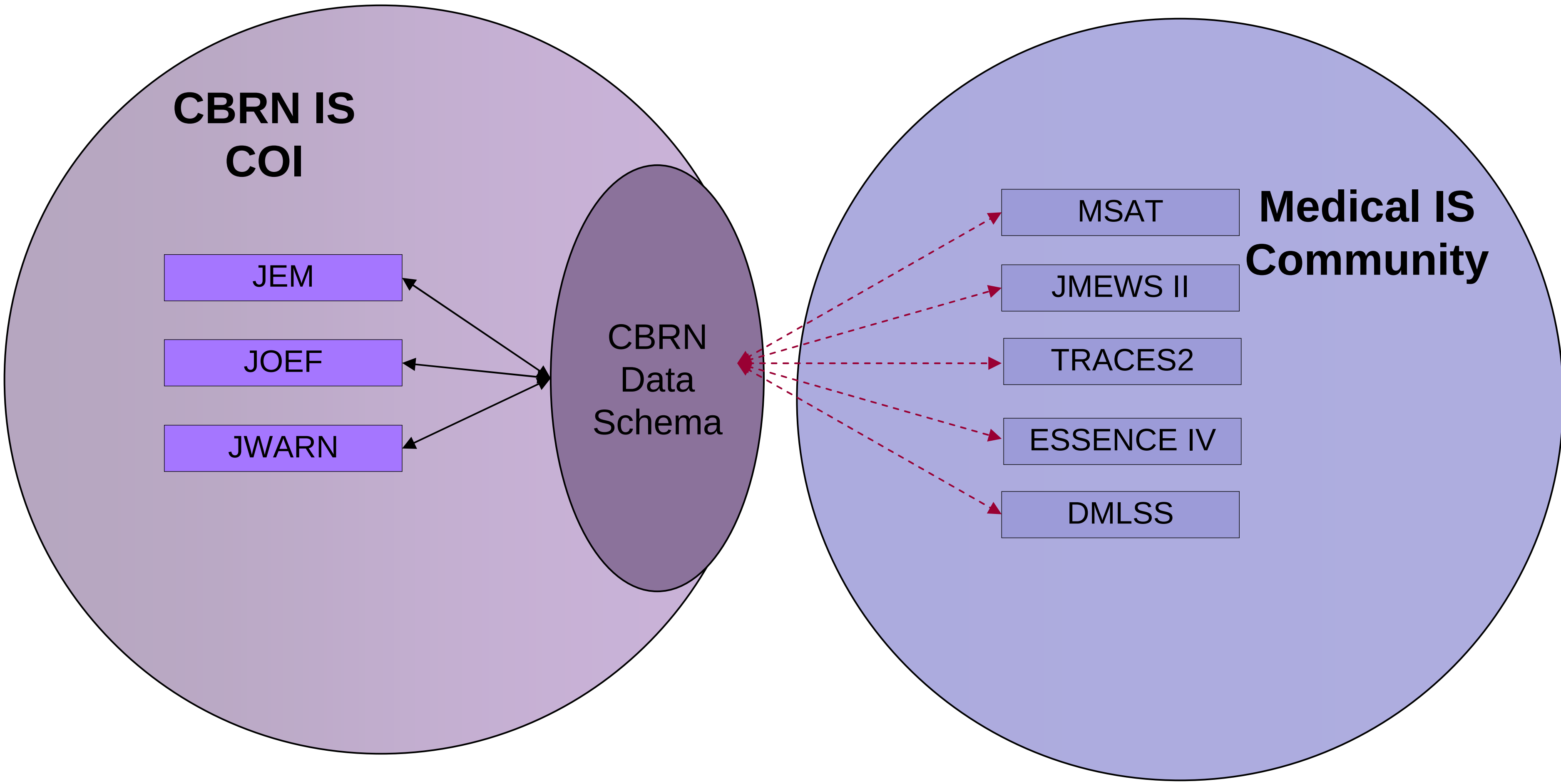
- Current approach:
  - Does not have an identified medical end-point / server
  - Is not scalable and is a stove-piped "file-based" solution
  - Does not provide an agreed upon Data Model / Schema for sharing of data between Medical, CBRN and other COIs
  - Does not support real time data exchange "manually intensive"
  - Does not meet DoD's direction for "net-centric" services

CBRN ⇔ Medical
System to System Data Exchange



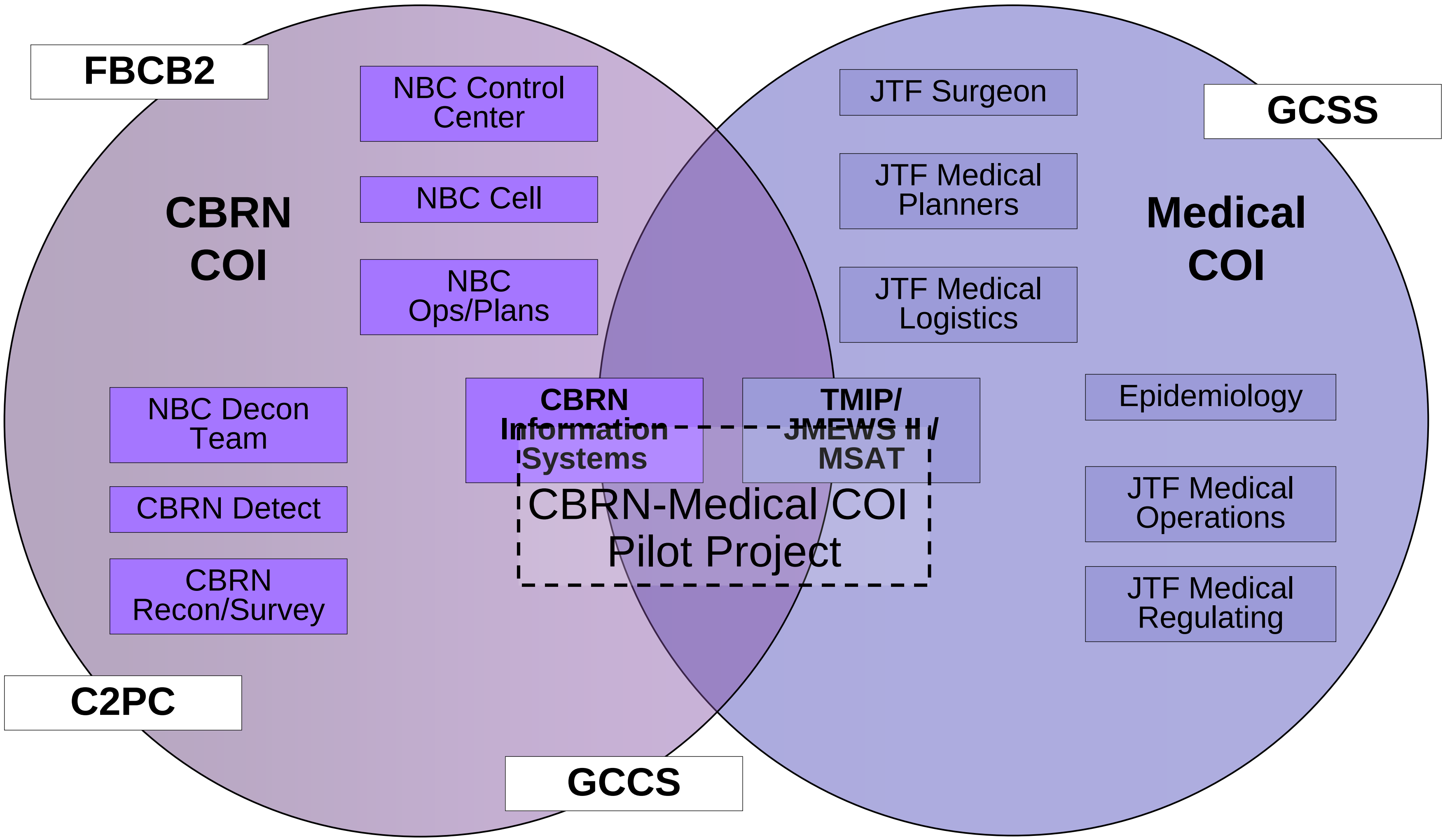
CBRN COI ⬄ Medical Notional Interfaces

Pilot Project (Phase 1)



CBRN ⬄ Medical COI Data Sharing

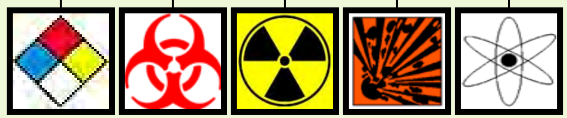
Pilot Project (Phase 2)



CBRN IS ⇔ Medical IS Data Sharing

CBRN

Systems
Sensors

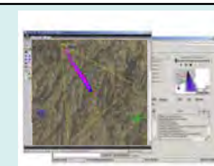


Collect/ Process

CBRN IS

JWARN
JEM
JOEF

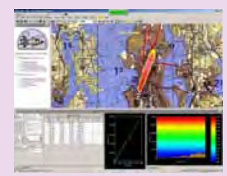
CBRN-Medical Pilot Project



Process/ Analyze/ View

MED IS

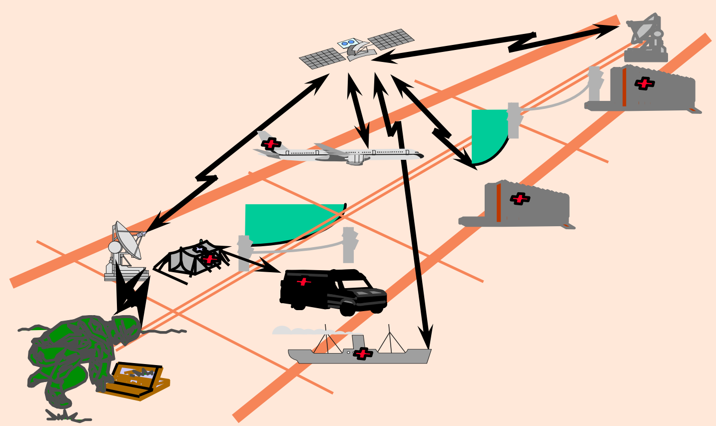
TMIP
JMEWS II
MSAT



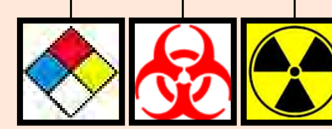
Process/ Analyze/ View

MEDICAL

Systems
Sensors



Collect/ Process



Sample Use Cases for Data Sharing

- **Medical Surveillance**
  1) Low Level/Long Term Exposure
- **Crisis Planning/Action**
  2) WMD Hazard Alert/Prediction
  3) Casualty Prediction
  4) Medical Logistics Requirements


Medina
Beaux Arts
Mercer Island City

JMEWS-II Application |Beds - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://localhost/msa-app/theaterbeds.do Go Links SnagIt

CLASSIFICATION LEVEL HERE

TMIP | Joint Medical Workstation II

Welcome back, System Administrator
Home Page Manage Filters Help Logout

Unit Status | Surveillance | Map View | AnnexQ Reporting | Search | Administration | Preferences

Current Status | Bulletin Board | Subjective | Blood | Equipment | Supplies | Beds | Event View | AnnexQ Report Status

Your Location: Unit Status > Beds

Your Filters: PACOM Only, consisting of 10 Units in: PACOM (Change filter) (Remove filter) (View Units in filter)

Bed Status

This page displays the most recent bed status, as reported by units in their most recent AnnexQ report.

8 of 10 joined units (80%) have filed **MedSitRep** in the last 4 day period.

Type	Authorized	On Hand	Mission Capable	Total Occupied	USA	USAF	USN	USMC	USCG	Non-US Military	EPW	US Civilian	Other Civilian	Other	Status
Level 2 beds	656	656	656	0	0	0	0	0	0	0	0	0	0	0	G

Export options: Excel | XML | CSV

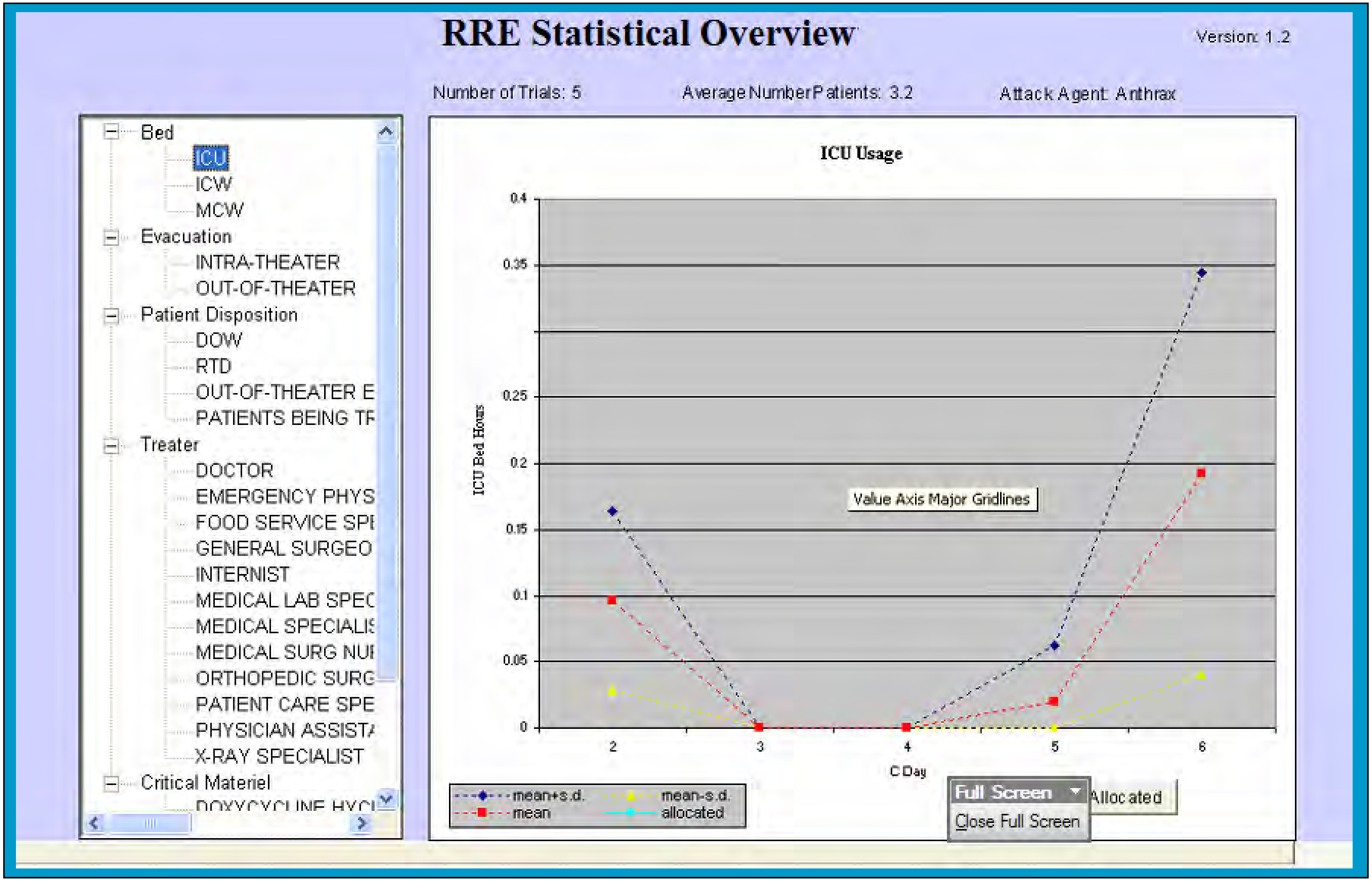
Key to this Chart

G - 0-30% Occupied **Y - 31-50% Occupied** **R - >50% Occupied**

Percentage occupied is defined as Total Occupied / Mission Capable Count.

This report shows data from the following Units: US ARMY: SamBAS (SAMBAS),CSH1 (CSH1),STAGING (STAGING),BAS1 (BAS1),CSH2 (CSH2),BAS2 (BAS2),BAS3 (BAS3),BAS4 (BAS4),MTF (MTF),CSH3 (CSH3)

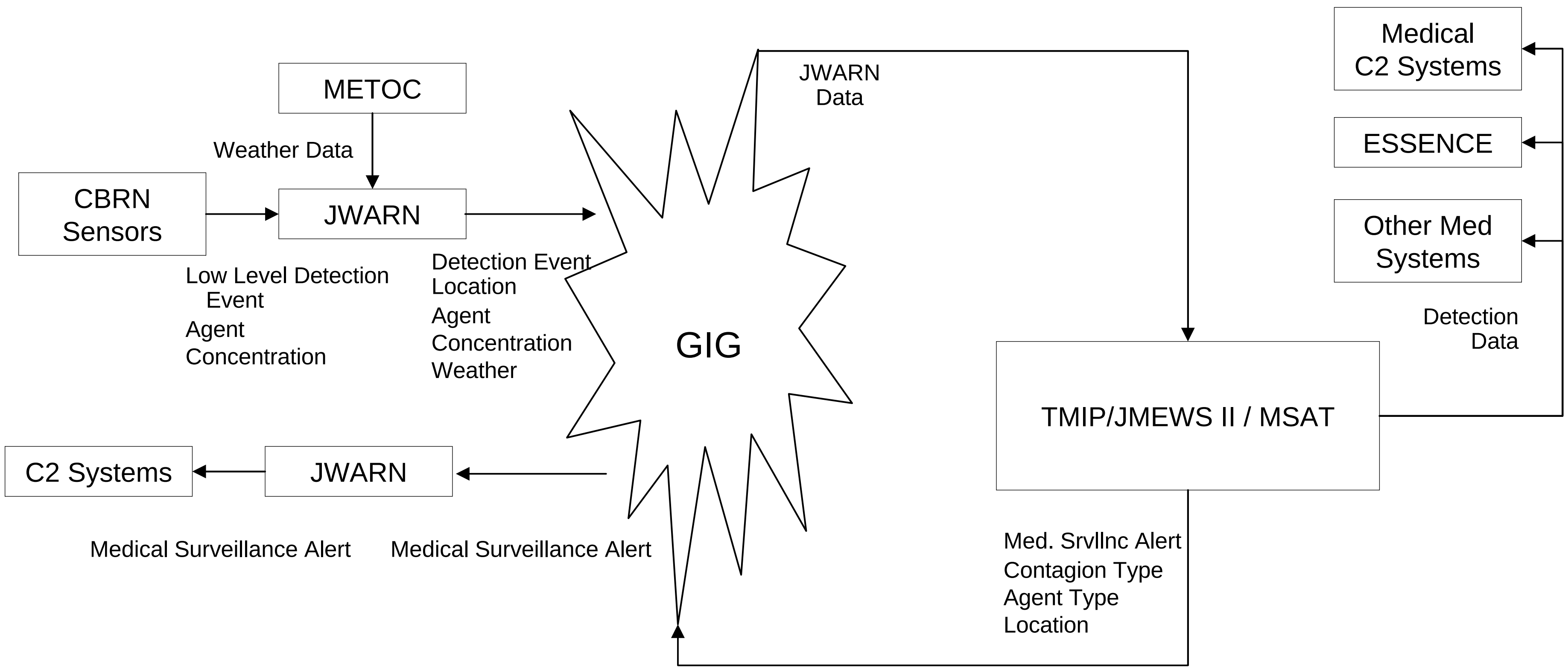
Operational Planning - JOEF



Medical Surveillance

1) Low Level/Long Term Exposure

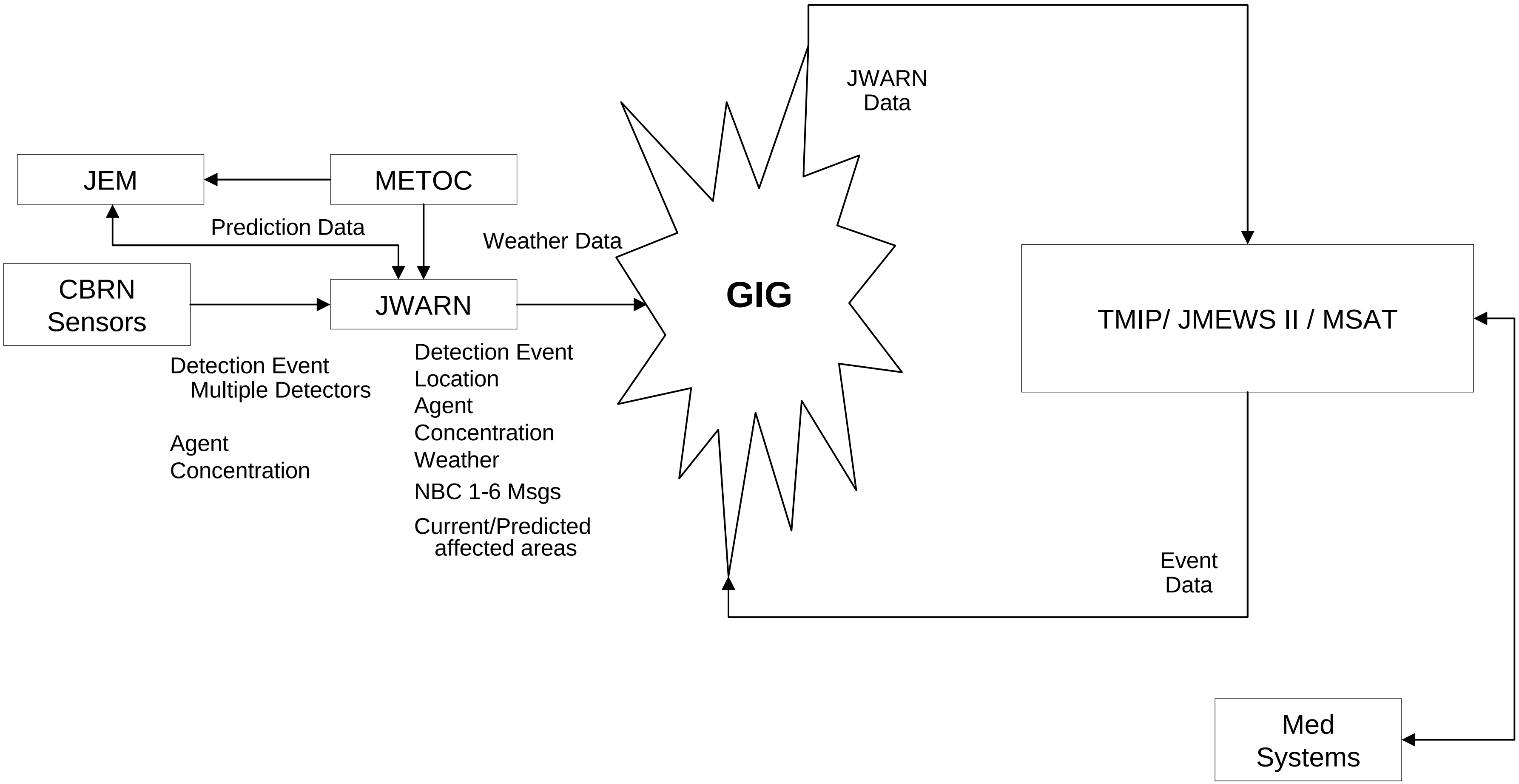
a) Raw detector data from CBRN sensors used by Medical Applications to accomplish long term surveillance.



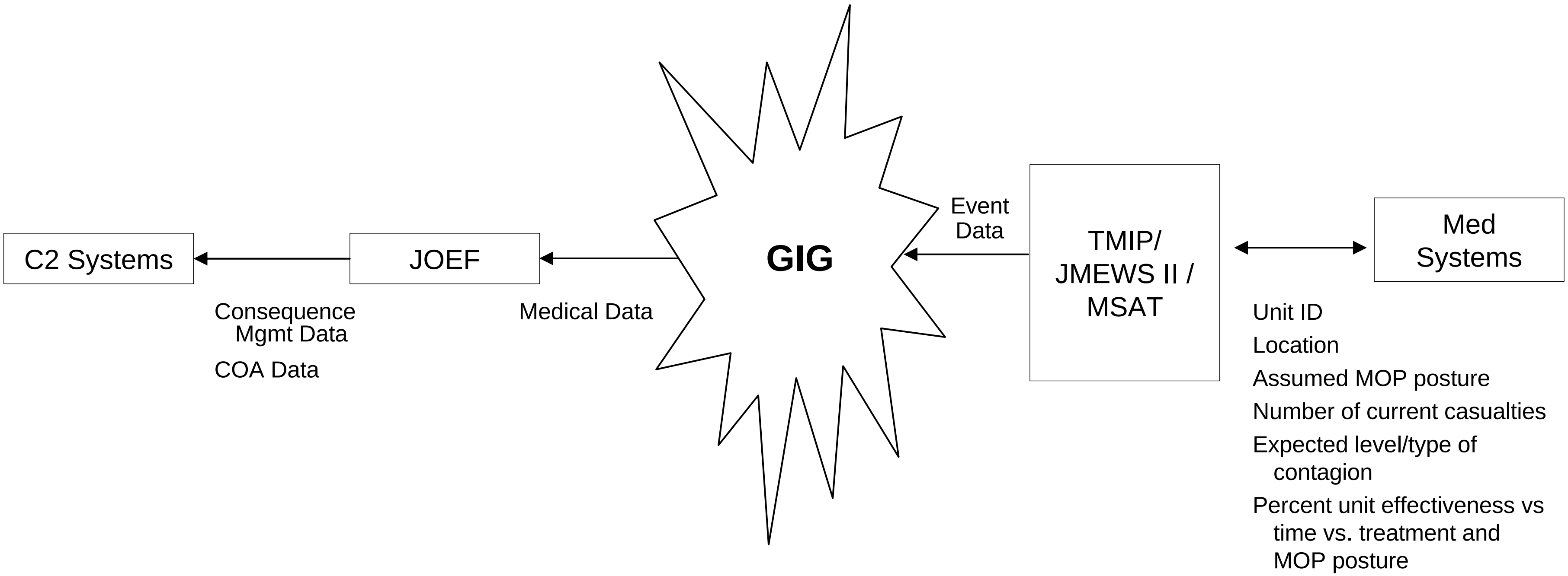
b) Medical COI Alerts to CBRN COI of long term events/hazards

Crisis Planning/Action

2) WMD Hazard Alert/Prediction

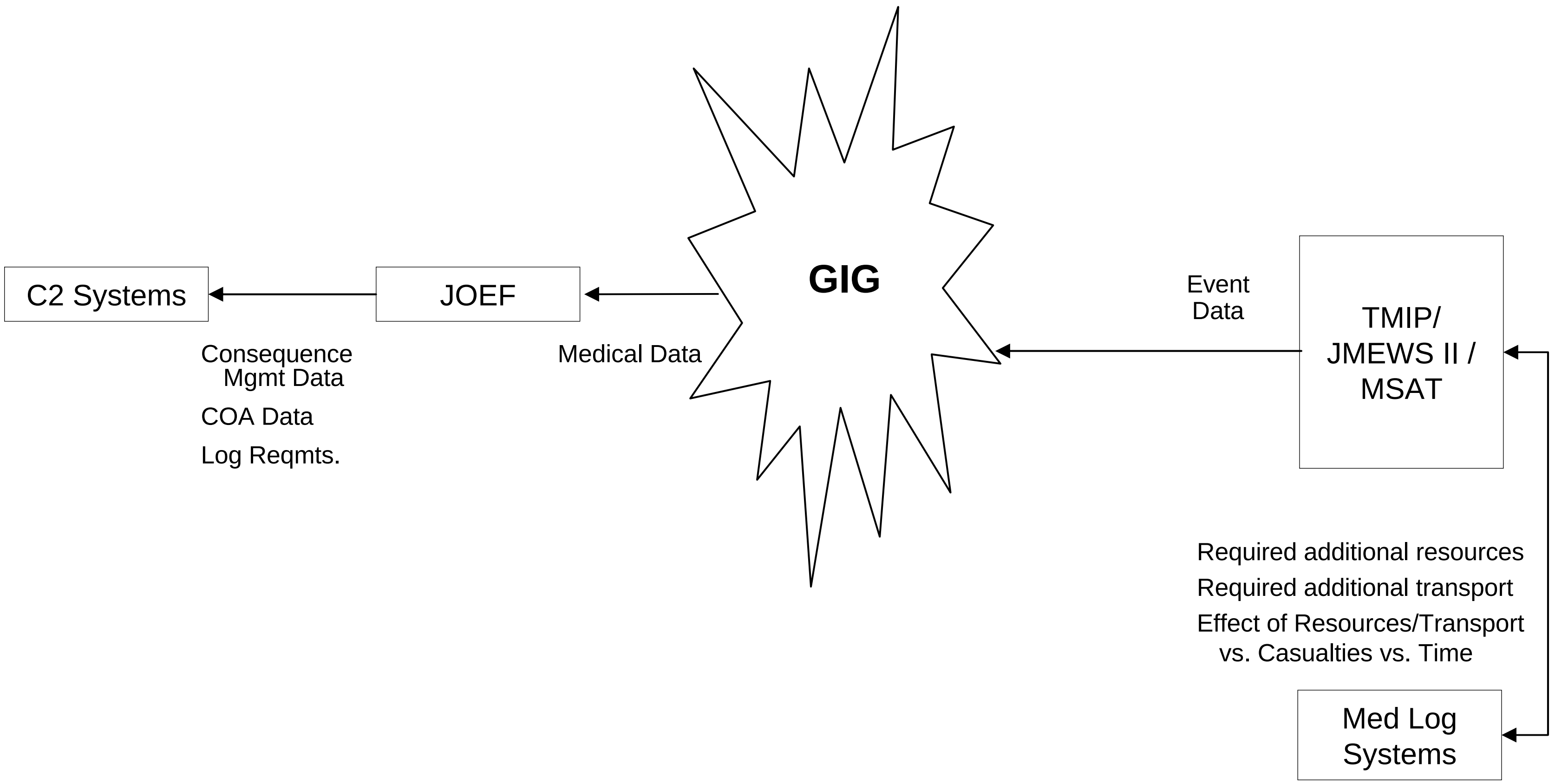


Crisis Planning/Action
3) Casualty Predictions

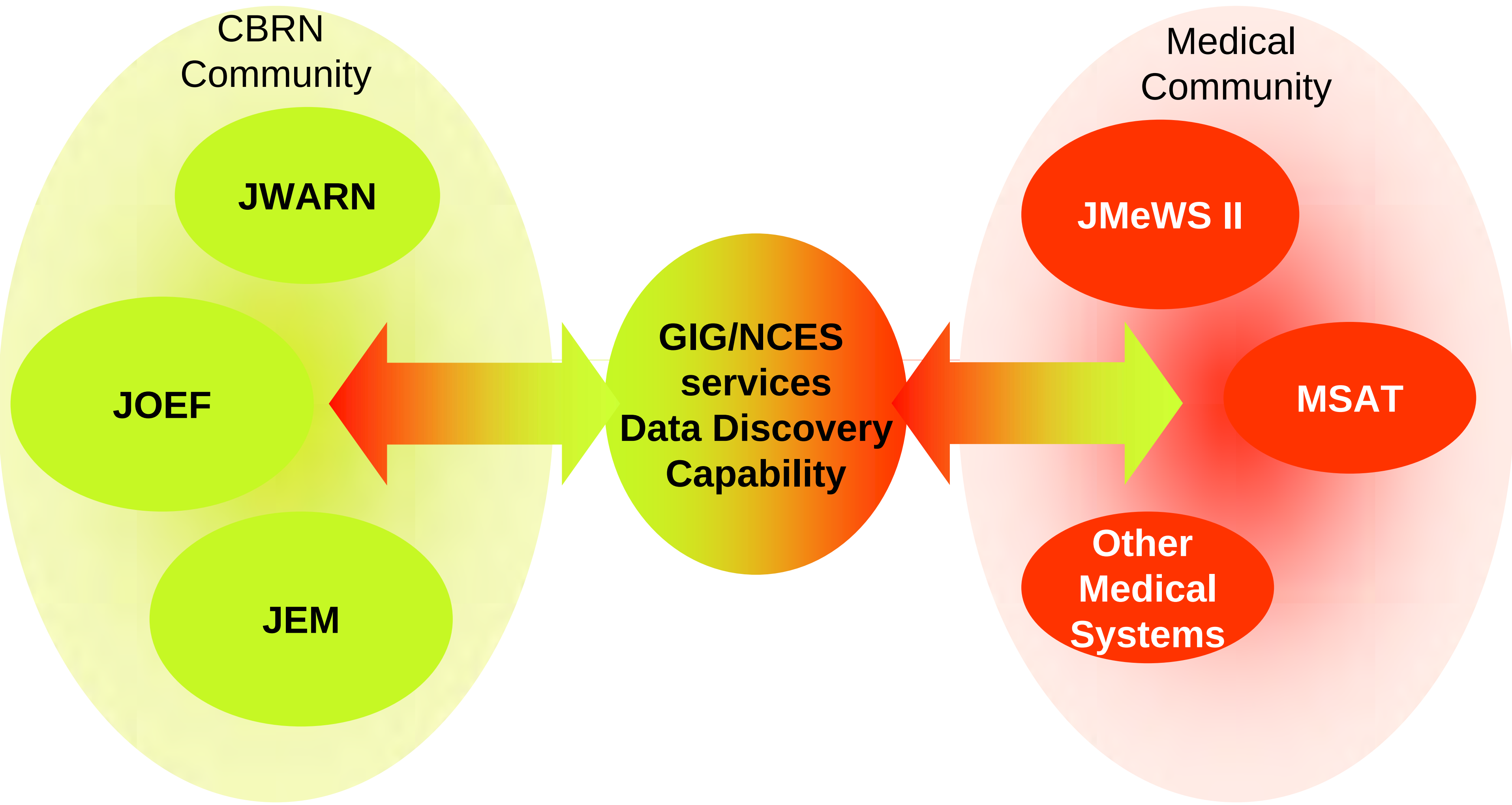


Crisis Planning/Action

4) Medical Logistics Requirements



CBRN ⬄ Medical Interoperability



Phased CBRN ⇔ Medical Migration

Current (JWARN=>TMIP)	Phase 1 (CBRN⇔MSAT)	Phase 2 (CBRN⇔MSAT)
• No CONOPS (CBRN-Med Data Sharing) →	• Develop CONOPS based on "best of" Use Cases →	• Refine Phase 1 CONOPS (Identify additional CONOPS use cases)
• One-way sharing (push only from CBRN to Medical) →	• Develop technology for sharing on GCCS-X Platforms (initial IER's) →	• Develop Shared Data Models and Schema
	• Use Legacy COE for Interoperability →	• Prototype NCES-based Web-Services for GIG Interoperability
		• Address backward compatibility to Legacy COE

time

Way Forward

- ✓ Brief out to MSAT ACTD to get "thumbs up"/buy-in that they are the Pilot's best fit from Medical community
- Receive S&T Resource Support for CBRN to participate in MSAT ACTD for CBRN ⇔ Medical Initial Capability Demonstrations
- Preparation of Pilot MOU/MOA (time-phased technical approach, resource commitment, expected outcome)

COORDINATING CB ENGAGEMENT SCENARIOS WITH THE CBRN DATA MODEL

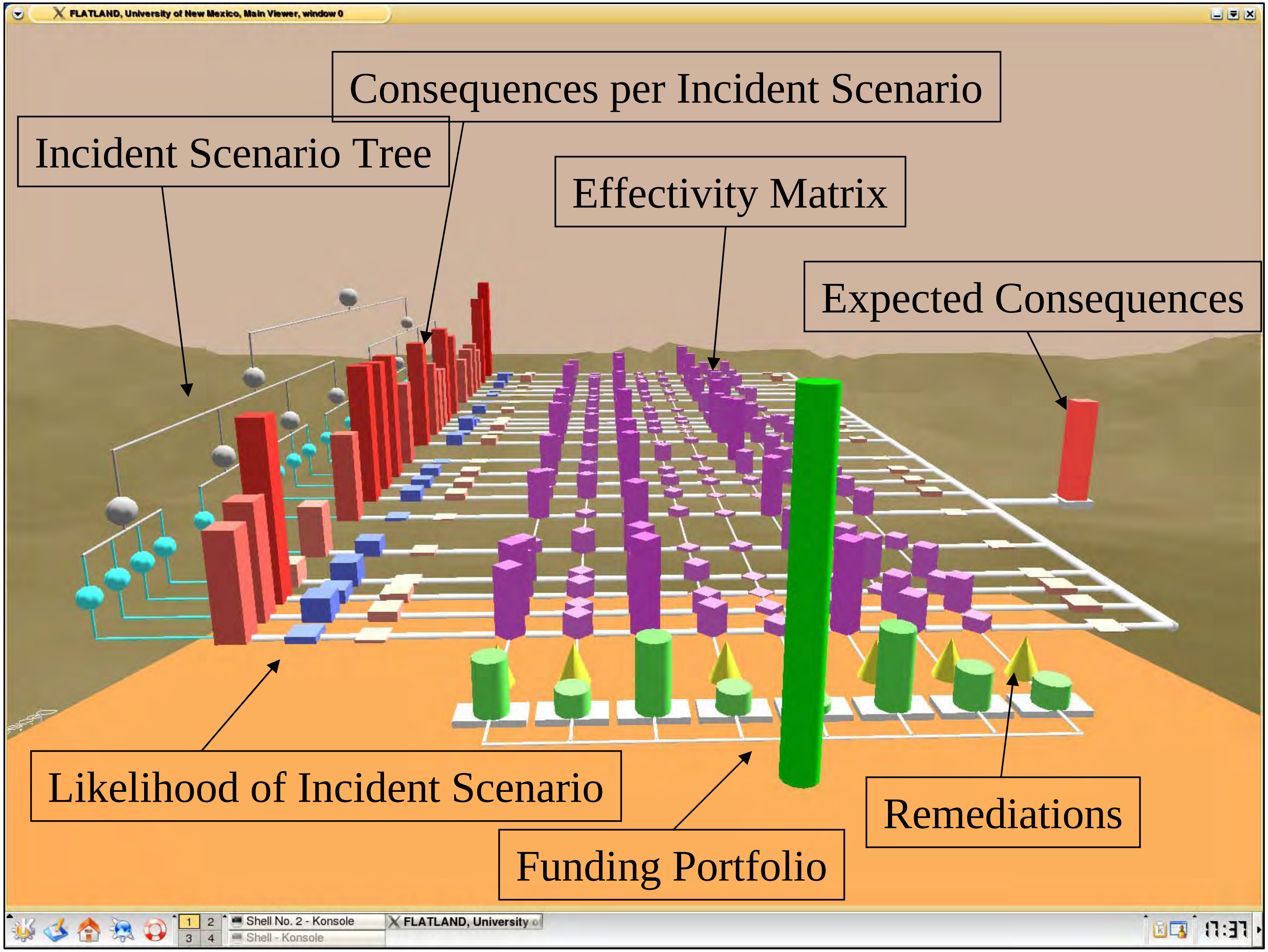
by

Stephen Helmreich
Computing Research Laboratory / NMSU
Sundara Vadlamudi, Markus Binder
Monterey Institute of International Studies

OUTLINE

- Introduction
- CB Scenarios – General
- CB Scenarios – Detail
- CB Scenarios and the CBRN Data Model
- Conclusion

Visualization of Mockup System



Criteria for a useful CB incident scenario

- Able to deal with uncertainty
- Accessible to experts
- Compatible with deeper scenarios
- Can be used to generate interpolated scenarios
- Can deal with hypothetical improvements to defensive measures

Utility of the CB incident scenario

- For S&T funding allocations for CB research
- For development / deployment of CB mitigation projects
- For similar tasks in similar areas (e.g., RN research, development, deployment)
- For other tasks requiring similar capabilities

CB incident scenario detail

- Inherent vulnerability
- Inherent characteristics
- Defensive measures
- Cost/impact

Inherent vulnerability-1

Inherent Vulnerability	Parameter	Range of Values / Units
Agent Characteristics (CW)	Agent	One of the following: {Sarin, soman, tabun, VX, mustard, lewisite, chlorine, hydrogen cyanide, phosgene, cyanogens chloride}
	Persistency	low / medium / high
	Ect50	(mg-min/m^3)
	Time for effect	minutes
	Mortality (untreated)	0%-100%
	Prophylaxis available	YES / NO
	Treatment available	YES / NO

Inherent vulnerability-2

Inherent Vulnerability	Parameter	Range of Values / Units
Agent Characteristics (BW)	Agent	One of the following: {anthrax, botulinum toxin, ricin, smallpox, yersinia pestis, glanders, tularemia, brucellosis}
	Sunlight Degradation Rate	0%-100% / minute
	Ect50	(mg-min/m^3)
	Incubation period	days
	Mortality (untreated)	0%-100%
	Vaccine	YES / NO
	Treatment available	YES / NO
Disperal Pattern	Mode of agent delivery	Point Source / Line Source

Inherent characteristics-1

Inherent Characteristics	Parameter	Range of Values / Units
Proximity to Civilian Infrastructure	Civilian infrastructures close to facility	One or more of the following: {major highway; civilian airport; city center; civilian port; other high-density civilian population}
Air Flows	Prevailing wind direction	(Compass coordinates, e.g. NE, SSE,W, etc.)
Ambient Temperature	Prevailing temperatures in target area at time of attack	Degrees fahrenheit
Time of Attack	Time of day	HH:MM

Inherent characteristics-2

Inherent Characteristics	Parameter	Range of Values / Units
Access to Offsite Medical Service	Rating of facility where "0" represents a facility with no immediate access to an offsite medical service and "5" represents immediate access to a large well-equipped medical service	0-5
Access to Civilian Hazmat Response	Rating of facility where "0" represents a facility with no access to a Hazmat team and "5" represents immediate access to a large well-equipped Hazmat team	0-5

Defensive measures-1

Defensive Measure	Parameter	Range of Values / Units
Chemical Agent Detector	Type	C1, C2, C3, …,C27,… (0 indicates null set)
	Agents detectable by sensor	One or more of the following: {Sarin, soman, tabun, VX, mustard, lewisite, chlorine, hydrogen cyanide, phosgene, cyanogens chloride}
	Range of detection	(in meters)
	Time for detection	(in minutes)
	False positive rate	0%-100%
	False negative rate	0%-100%
	Number of detectors deployed at facility	(integer)

Defensive measures-2

Biological Agent Detector	Type	B1, B2, B3,…,B27,… (0 indicates null set)
	Agents detectable by sensor	One or more of the following: {anthrax, botulinum toxin, ricin, smallpox, yersinia pestis, glanders, tularemia, brucellosis}
	Range of detection	(in meters)
	Time for detection	(in minutes)
	False positive rate	0%-100%
	False negative rate	0%-100%
	Number of detectors deployed at facility	(integer)

Defensive measures-3

Perimeter Protection	Presence of wall and fence	YES / NO
	Presence of barricaded gates	YES / NO
	Number of armed guards	(integer)
	Anti-missile Defense	YES / NO

Defensive measures-4

Protective Equipment	Mask Type	MK1, MK2, MK3, …,MK27,… (0 indicates null set)
	Avbl of Masks	0%-100%
	Suit Protection factor	(0-5)
	Mask Wearability	(0-5)
	NBC Suit Type	S1, S2, S3, …,S27,… (0 indicates null set)
	Avbl of NBC Suits	0%-100%
	NBC Suit Protection factor	(0-5)
	NBC Suit Wearability	(0-5)
	Positive pressure system	YES / NO
	Personnel indoors	0%-100%

Defensive measures-5

MOPP Level	Level of defense preparedness	MOPP 1-4
Trained Onsite Personnel	Rating of facility, where "0" represents a facility with no dedicated medical response team with CB defense training and "5" represents a facility with a dedicated CB response team.	0-5

Defensive measures-6

Chemical Prophylaxis	Type	PC1, PC2,…PC21,… (0 indicates null set)
	Agents effective against	Nerve agents, blood agents, choking agents, vesicants
	Risk level of side-effects – combined measure of probability and severity	low / medium / high
	Effectiveness	low / medium / high
	Maximum number of days safe to take prophylaxis continually	(integer)
	Number of days before prophylaxis becomes effective	(integer)
	Minimum number of days between pre-treatment cycles	(integer)
	Average percentage of base personnel receiving prophylaxis at any given time under normal conditions	0-100%

Defensive measures-7

Defensive Measure	Parameter	Range of Values / Units
Biological Prophylaxis	Type	PB1, PB2, …, PB42,… (0 indicates null set)
	Agents effective against	anthrax, botulinum toxin, ricin, smallpox, yersinia pestis, glanders, tularemia, brucellosis
	Risk level of side effects	Low / medium / high
	Effectiveness	Low / medium / high
	Number of days after inoculation commences before prophylaxis is effective	(integer)
	Duration of effectiveness in days	(integer)
	Percentage of base personnel inoculated	0-100%

Defensive measures-8

Medical Treatment (Chemical)	Type	MT1, MT2,…,MT47,… (0 indicates null set)
	Agents effective against	Nerve agents, blood agents, choking agents, vesicants
	Effectiveness	0-5
	Percentage of facility personnel covered by the antidote stockpile	0-100%
Medical Treatment (Biological)	Type	MT1, MT2,…,MT47,… (0 indicates null set)
	Agents effective against	Nerve agents, blood agents, choking agents, vesicants
	Effectiveness	0-5
	Percentage of facility personnel covered by treatment	0-100%

Impact/Cost

Impact / Cost	Parameter	Range of Values / Units
Casualties	Personnel killed or and / or injured	(integer)
Mission impact	Service dependent, (eg: Air-Force – Sortie generation rate reduction)	0-100%
Remediation costs	Cost to restore facility to full pre-attack capability	millions of $US
Geopolitical Impact	Affect on USG prestige	low / medium / high
S&T cost	Cost for research for new CB defensive measures	millions of $US
Deployment cost	Cost for fielding of new CB defensive measures	millions of $US
S&T time	Time to complete research for new CB defensive measures	(in months)
Deployment time	Time to complete fielding of new CB defensive measures	(in months)

Connections to the CBRN Data Model

- Top level: ACTIONs and OBJECTs
- ACTIONs are either EVENTs (unplanned) or TASKs (planned)
- Our SCENARIO is a conjoined CBRN-EVENT and a response TASK
- Connected by an ACTION-FUNCTIONAL ASSOCIATION
- OBJECTS are connected to the EVENTs and TASKs

Basic connections

- Inherent vulnerability – CBRN-EVENT / CHEMICAL-BIOLOGICAL-EVENT
- Inherent characteristics – FACILITY
- Defensive measures – ACTION-EVENT
- Cost/Impact – limited connection to Data model

Connections – Examples

- (Scenario) Air flows – (Data Model) WIND
- Agent – CHEMICAL/BIOLOGICAL-MATERIEL-TYPE
- Dispersal Mechanism – CBRN-EVENT-DELIVERY-MECHANISM
- Sensor – CBRN-SENSOR-TYPE

Connections – More examples

- Wall – WALL
- Gate – GAT
- Armed guards – GUARDN / GUARD
- Casualities – MEDICAL-FACILITY-STATUS-INTERVAL-CASUALTY-GROUP

Conclusions

- We have presented a detailed CB incident scenario that we believe is
  - Useful for our purposes
  - Is compatible with the CBRN Data Model
  - May be useful for other purposes

- Feedback? Questions?

Droplet Reaction and Evaporation of Agents Model

(DREAM)

Applied to HD on glass, DEM on glass and MS on glass

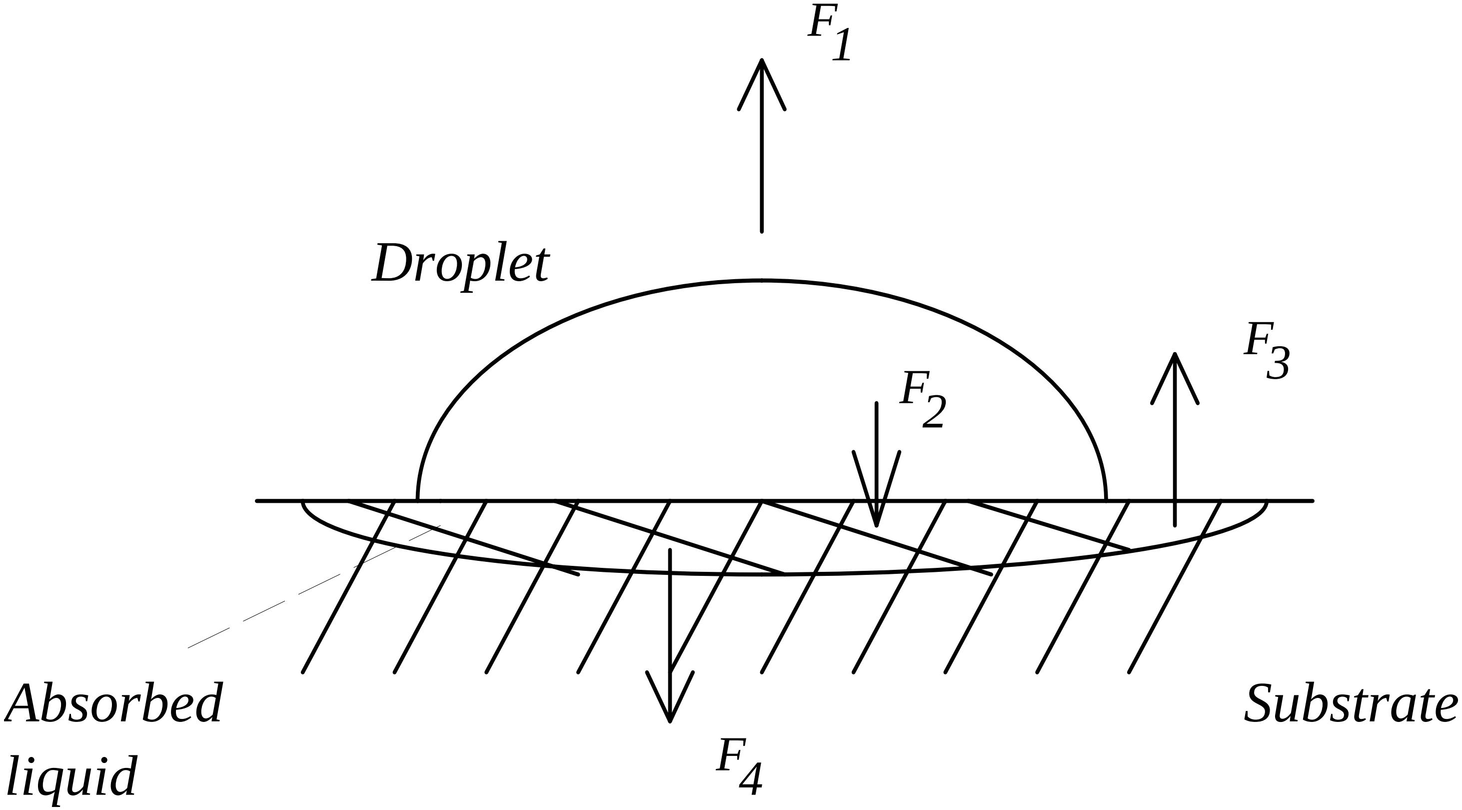
A.R.T. Hin - TNO, The Netherlands
(visiting scientist at AFRL)

26 October 2005

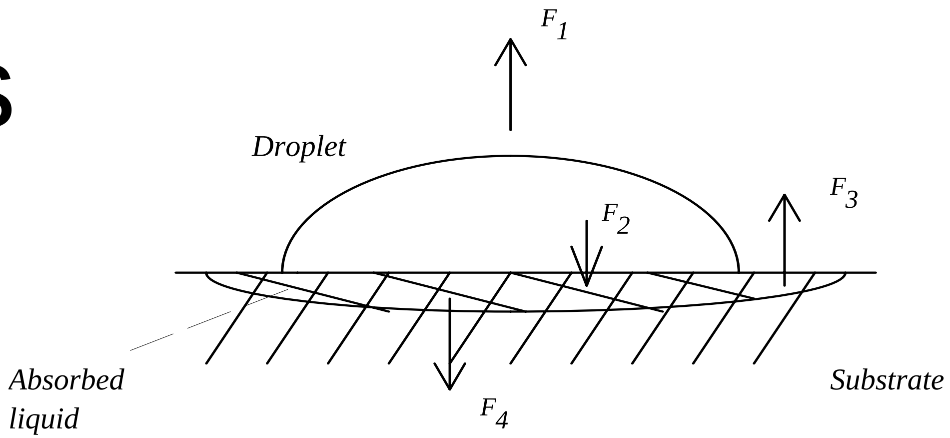
Outline

- Introduction
- Model
  - Sessile drop model
- Data
  - Dutch wind tunnel (HD, DEM and MS on Glass)
  - Czech wind tunnel (HD on Glass)
  - ECBC wind tunnel (HD on Glass)
- Fitting the model to the data

4 Transport rates



Develop in steps

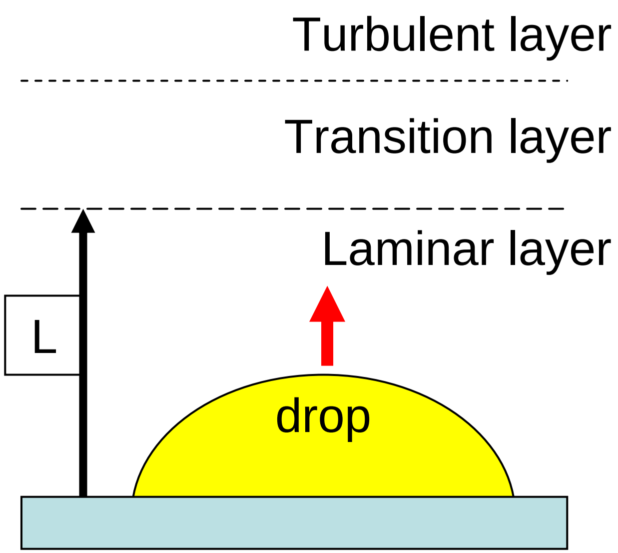


HD on Glass
MS on Glass
DEM on Glass

	Sessile Drop	Absorbed Drop
Neat Agent	Drops spread fast (seconds)	Drops absorb fast (minutes)
Thickened Agent	Drops spread slow (ten minutes)	Drops absorb slow (hours)

Add reactivity when significant chemical reactions are found

Sessile drop (F1)



- Drop mass over time

$$m(T) = m(0) - \int_0^T \dot{m}(t)\, d\, t$$

- Fick's law

$$d\, m(t) / d\, t = D\, A(t)\, (C_{skin} - C_{bulk}) / L$$

- Raoult's law (ideal mixtures)

$$P_{\text{agent in mixture}} = \text{Mol fraction}_{\text{agent in drop}} \times P_{\text{pure agent}}$$
$$C_{agent} = P_{agent}\ \text{Mol weight}_{agent} / (RT)$$

- Reactivity (implemented but not yet tested)

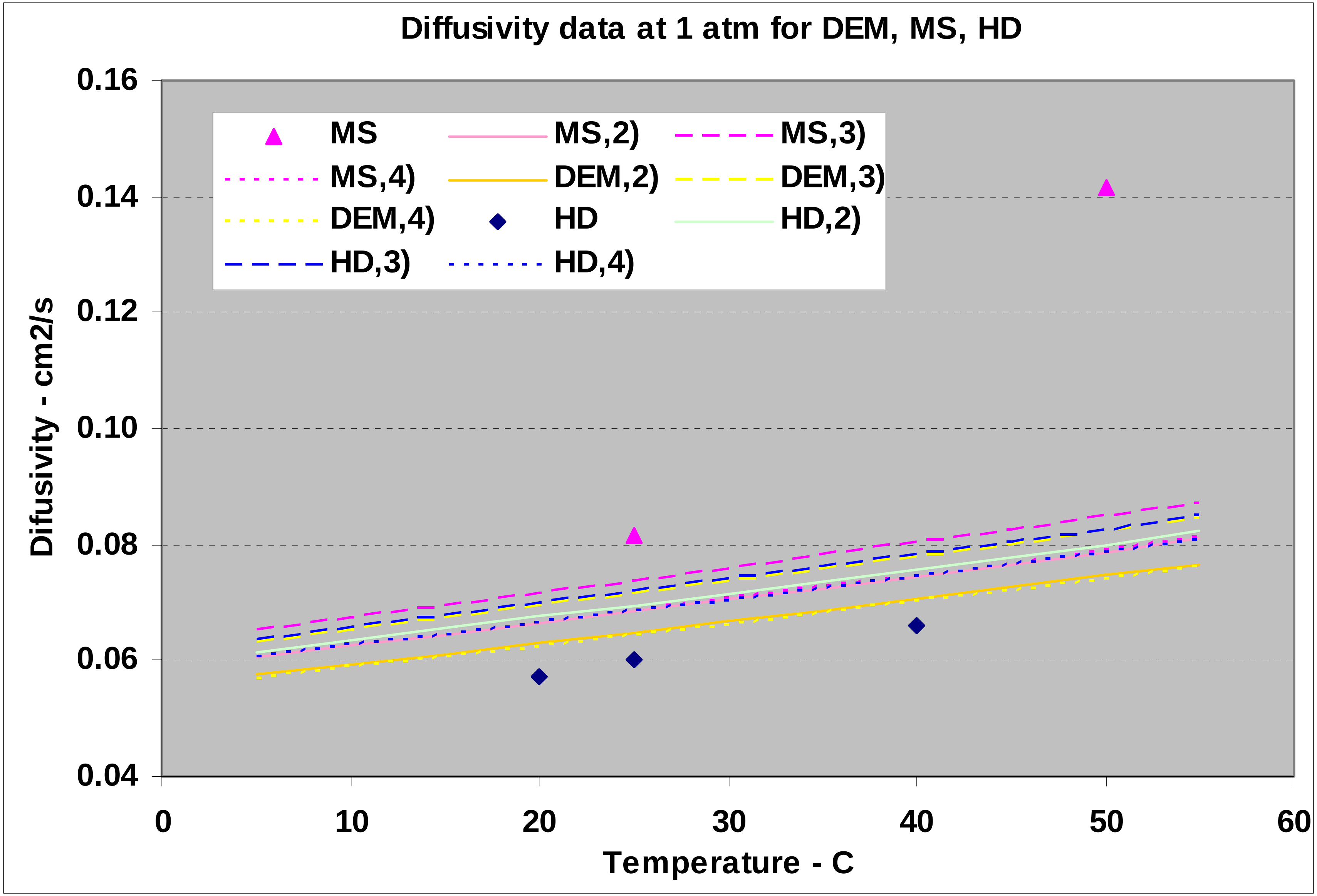
$$d[X]/d[t] = A_e\, e^{(-E/RT)}\, [X]^x\, [Y]^y$$

Diffusivity, D in air

- How ‘mobile’ are the molecules in air?
  - Depends on temperature, pressure, molecular mass, molecular volume, and air properties

- Two estimation methods found
  - Fuller,Schettler,Giddings method (Lyman et al. 1982)
    - All above dependencies
    - Not suitable for phosphor components: no molecular volume data
  - Simple method (Danish EPA)
    - Eliminates molecular volume dependence

Diffusivity Data and Estimations



Vapor Concentration at skin, C_{skin}

- Get vapor concentration from vapor pressure
  - Get 'volatility' using ideal gas law: C = P Mw / (R T)

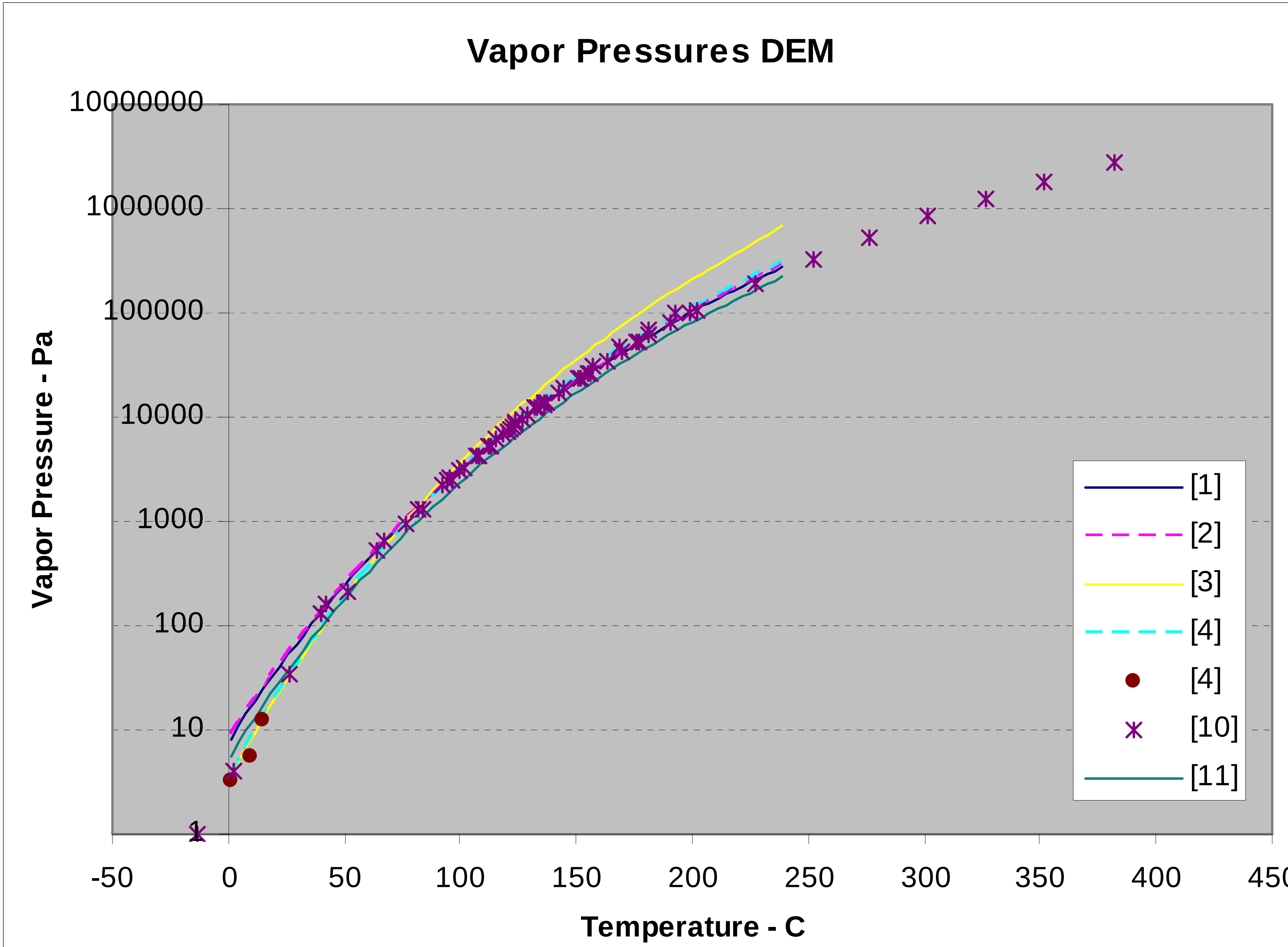
Antoine equation

$$P = 133.322*10^{a-b/(T+c)}$$

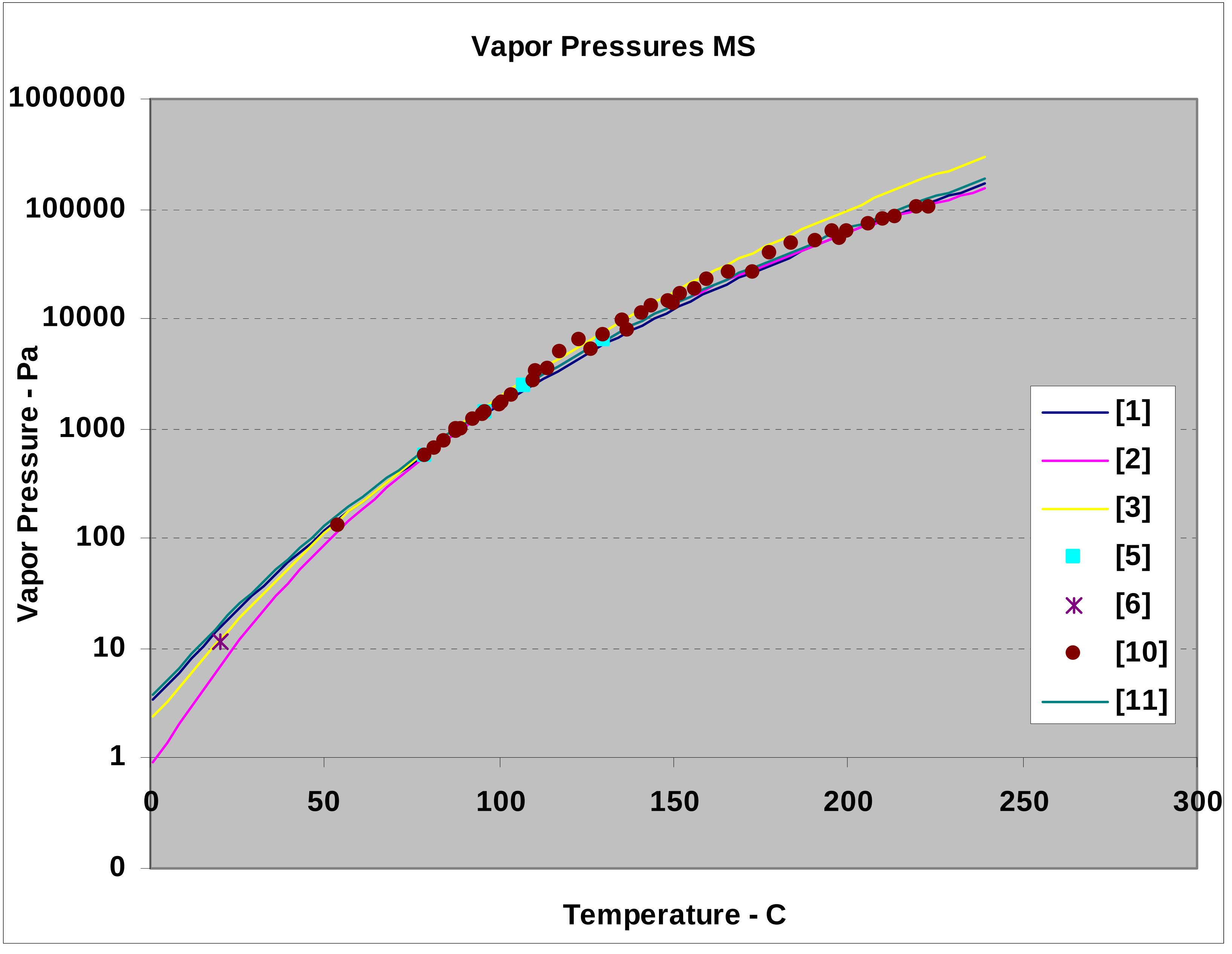
Clausius-Clapperon
Ideal gas

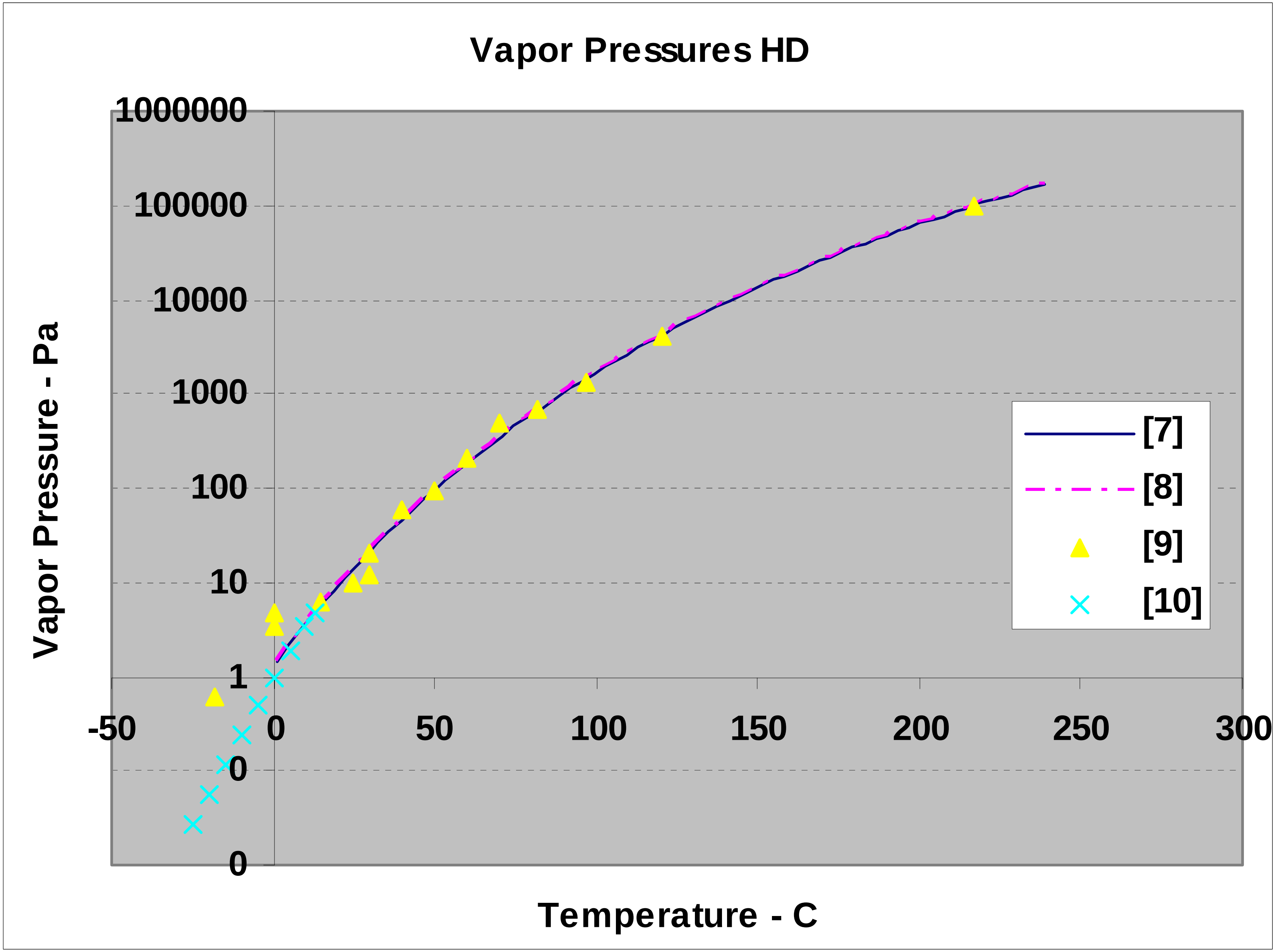
$$\ln \frac{p_2}{p_1} = -\frac{\Delta \overline{H}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

- Depends on
  - Agent
    - from data (if available)
    - or estimation methods
  - Temperature
    - Antoine equation (used for model)
      - three constants a,b,c fitted to data



Vapor Pressures DEM
Vapor Pressure - Pa
10000000
1000000
100000
10000
1000
100
10
1
-50
0
50
100
150
200
250
300
350
400
450
Temperature - C
[1]
[2]
[3]
[4]
[4]
[10]
[11]

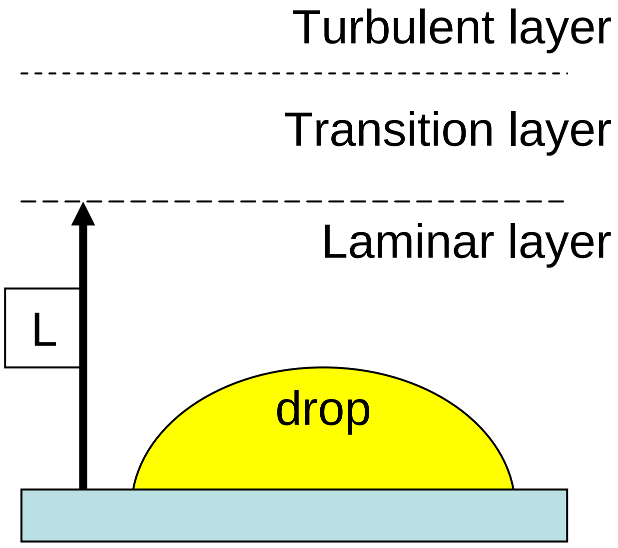

Vapor Pressures MS
Vapor Pressure - Pa
1000000
100000
10000
1000
100
10
1
0
0
50
100
150
200
250
300
Temperature - C
[1]
[2]
[3]
[5]
[6]
[10]
[11]



Vapor Pressures HD
Vapor Pressure - Pa
1000000
100000
10000
1000
100
10
1
0
0
-50
0
50
100
150
200
250
300
Temperature - C
[7]
[8]
[9]
[10]

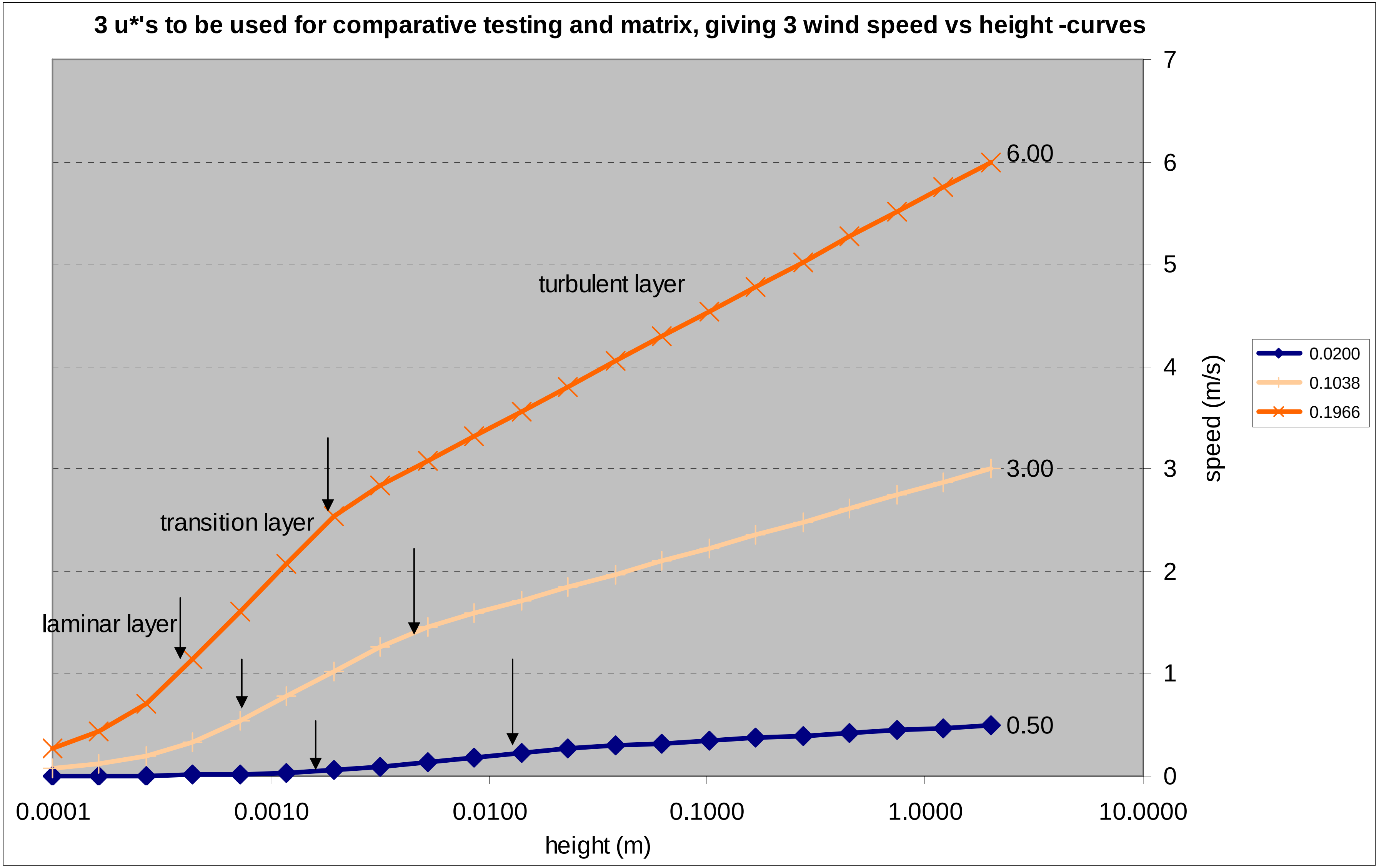
Diffusion layer thickness, L

- Depends on
  - wind speed
  - temperature (viscosity air)
  - pressure
  - on turbulence
  - drop size



- Empirical in semi-empirical model
  - Constant diffusion layer thickness for an experiment
  - ~ laminar layer thickness
  - order of magnitude: 1 millimeter
  - Fitted to data

Wind speed vs Height



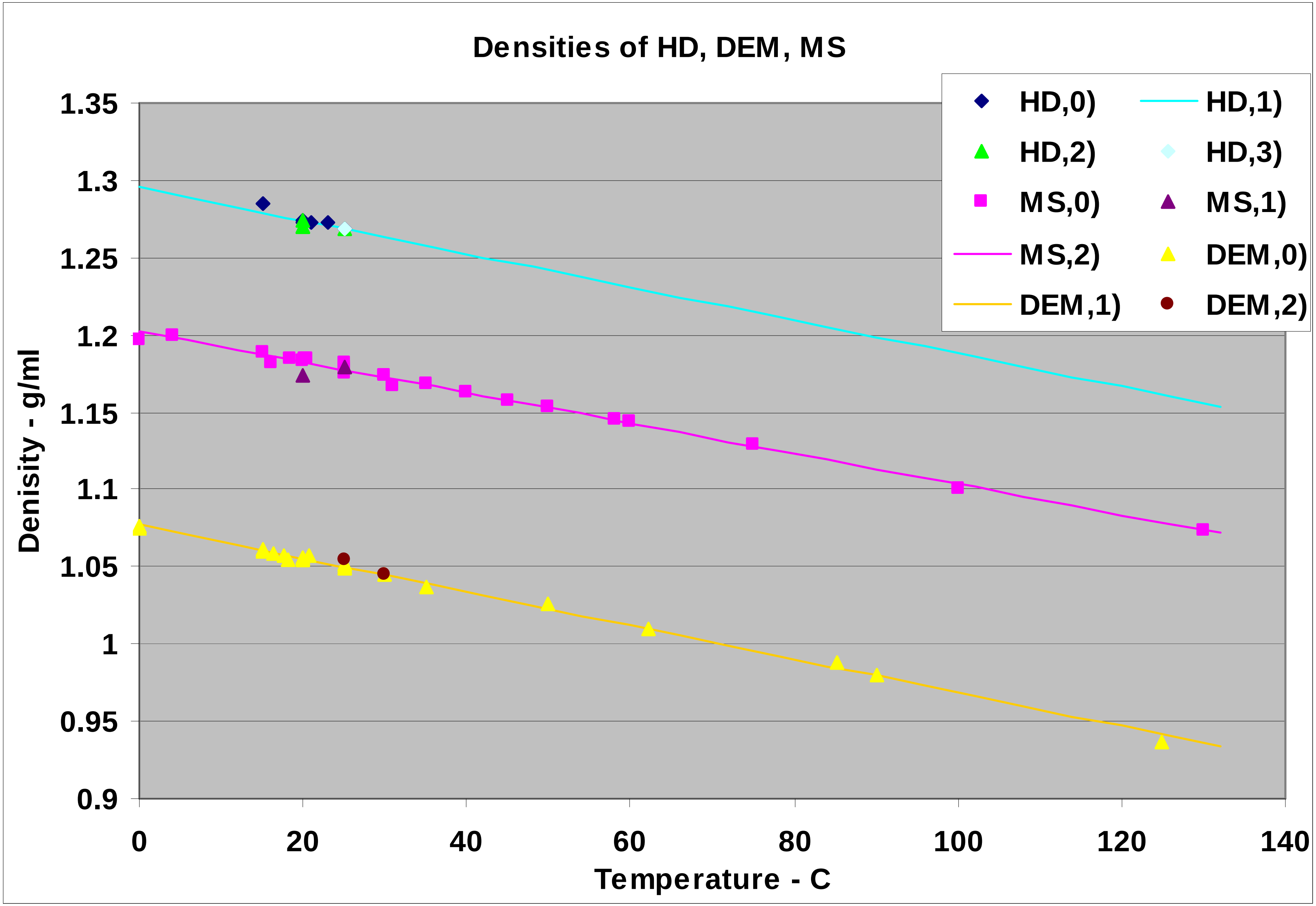
Area of evaporation, A(t)

- Volume from initial drop mass
    - Liquid density a function of agent and of drop temperature

- Shape over time
  - From observed shape and time behavior of sessile drops:

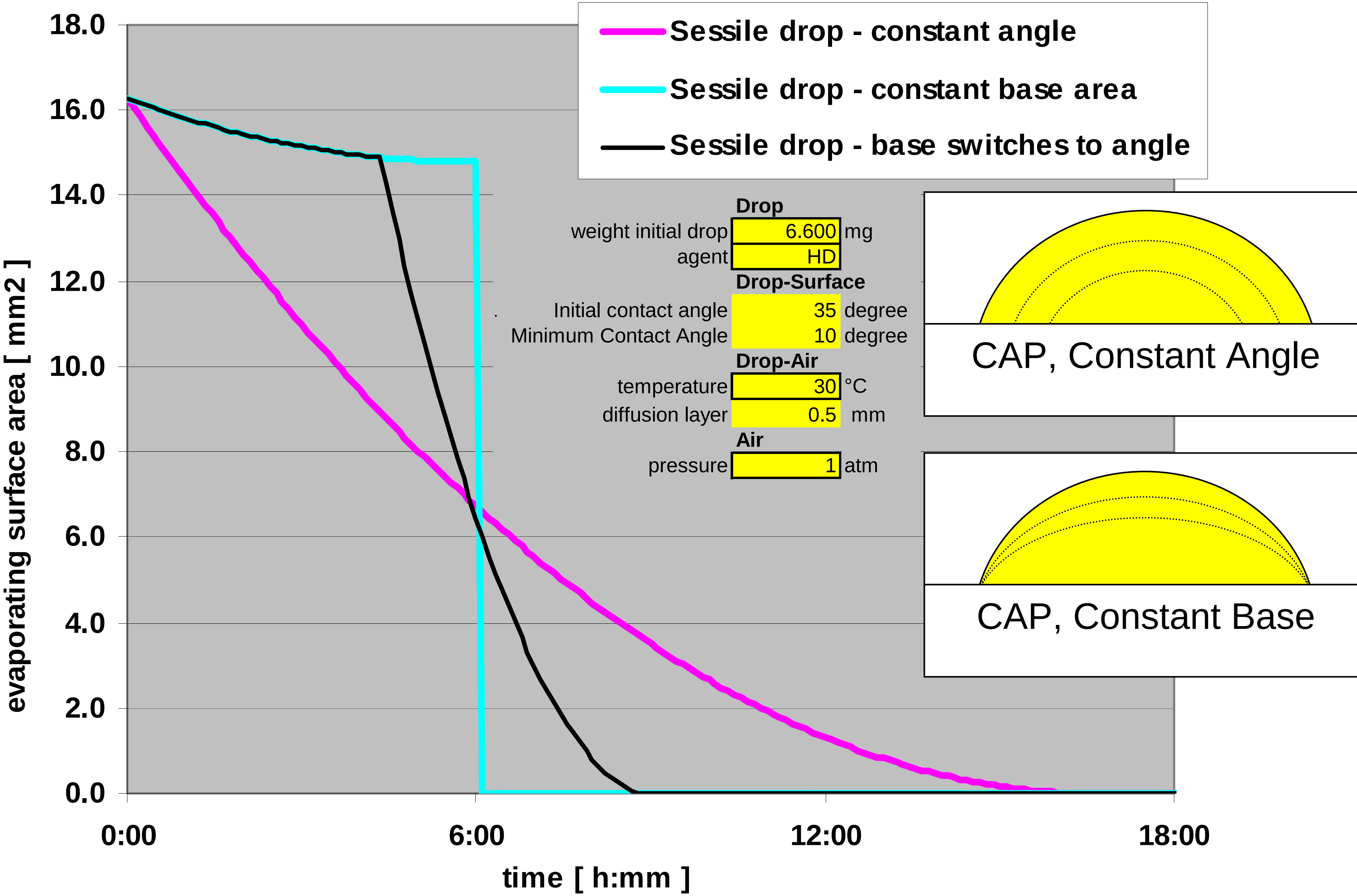
    One shape (spherical cap), but two modes needed

        - Constant base area mode
        - Constant contact angle mode

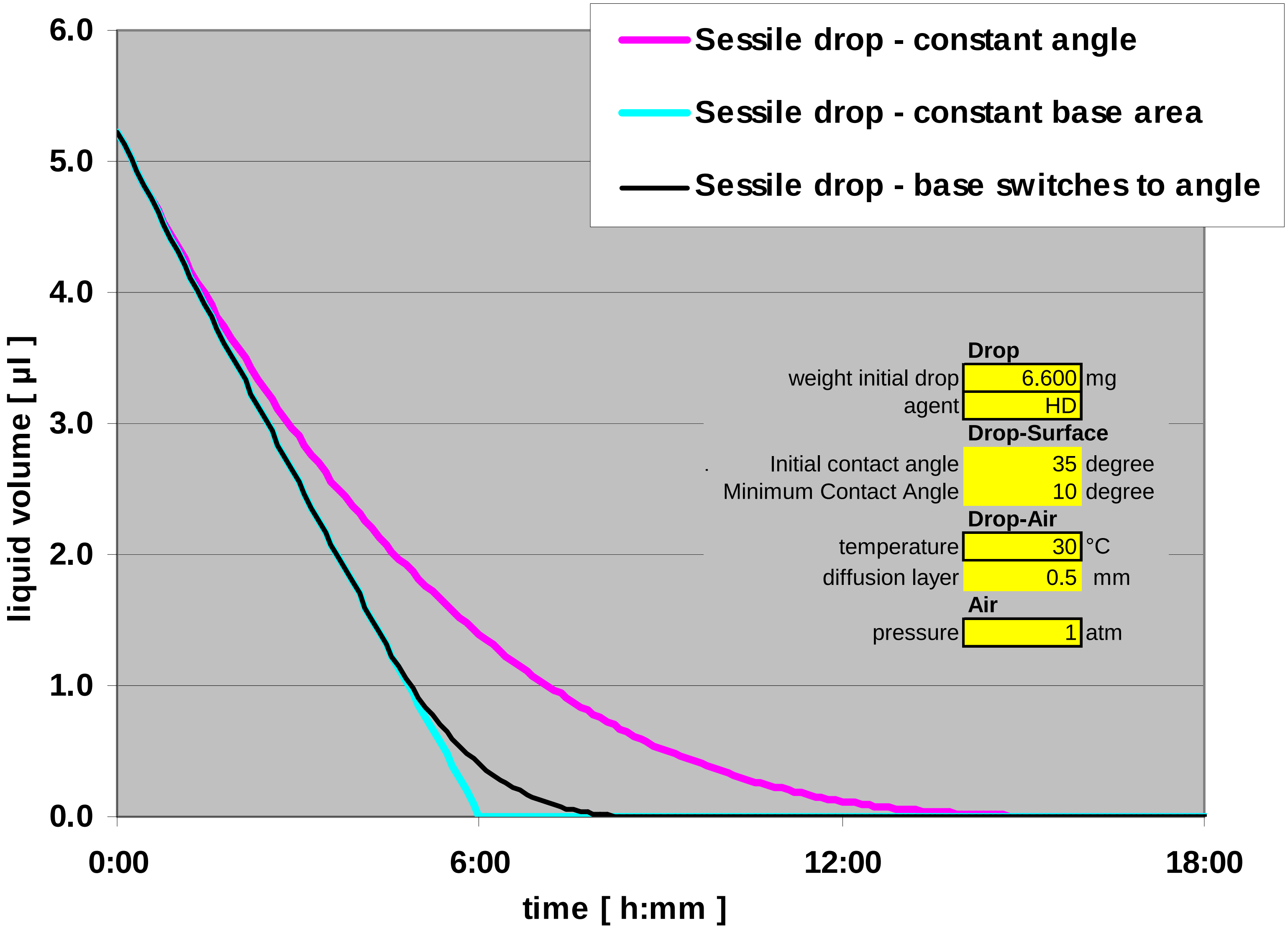


Densities of HD, DEM, MS
HD,0)
HD,1)
HD,2)
HD,3)
MS,0)
MS,1)
MS,2)
DEM,0)
DEM,1)
DEM,2)
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0
20
40
60
80
100
120
140
Denisity - g/ml
Temperature - C

Area of evaporation over time



Volume of drop over time

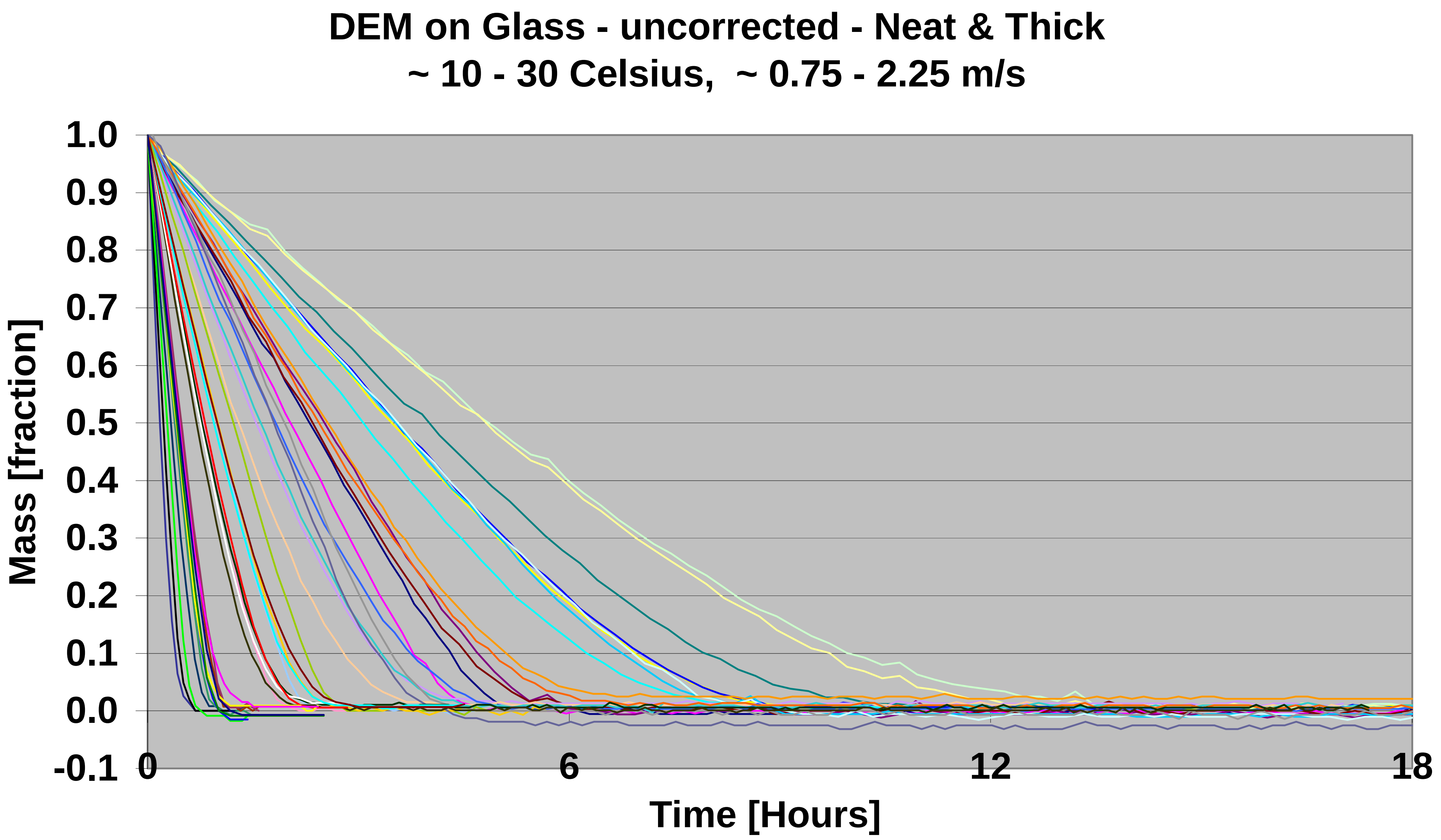


DATA

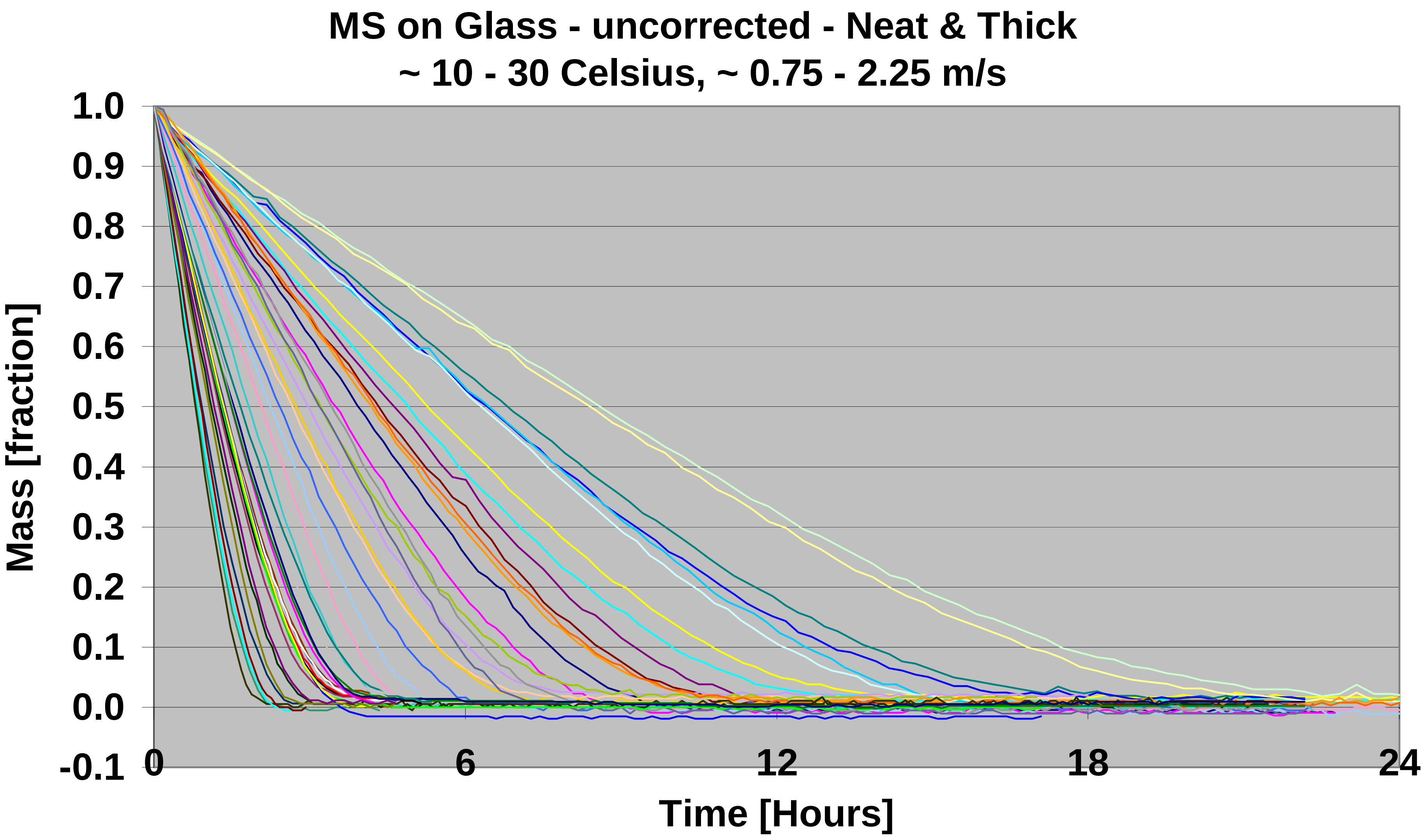
- Czech data
  - 30 mass over time curves HD on Glass
- Dutch data (neat and thick)
  - 42 mass over time curves DEM on Glass
  - 46 mass over time curves MS on Glass
  - 11 mass over time curves HD on Glass
- ECBC data
  - 5 mass over time curves HD on Glass

- Much more data on the way
  - UK, Czech, Dutch and ECBC
    - Establish proper tunnels performance
    - Compare effects tunnel size (and turbulence intensity)

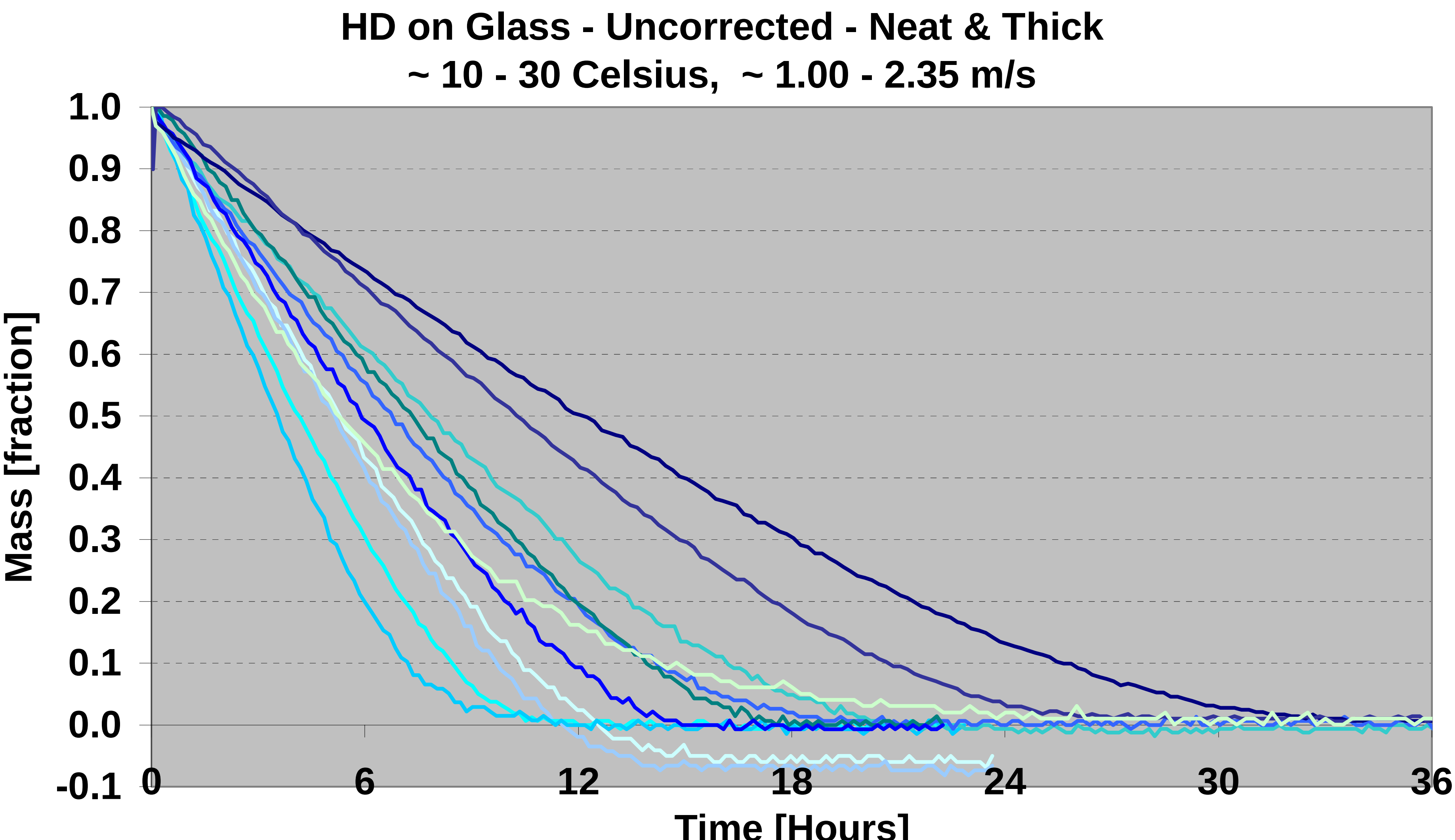
Dutch DEM data, 42 curves



Dutch MS data, 46 curves



Dutch HD data, 11 curves



Fitting the model to the data

used empirical fit functions for contact angles and ‘effective average diffusion layer thickness’

- Initial angle
- Minimum angle

assumed to depend on

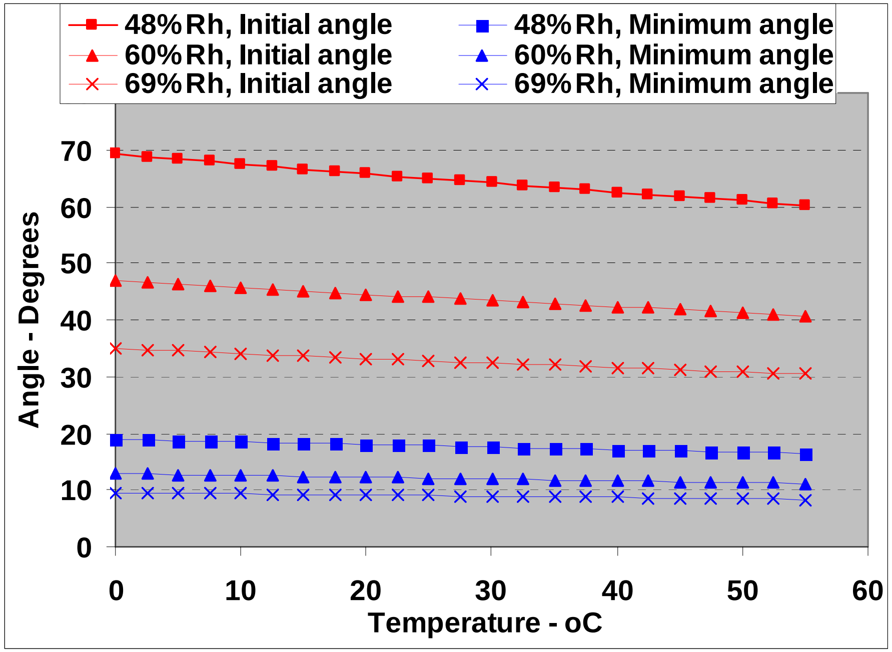
- temperature
- relative humidity

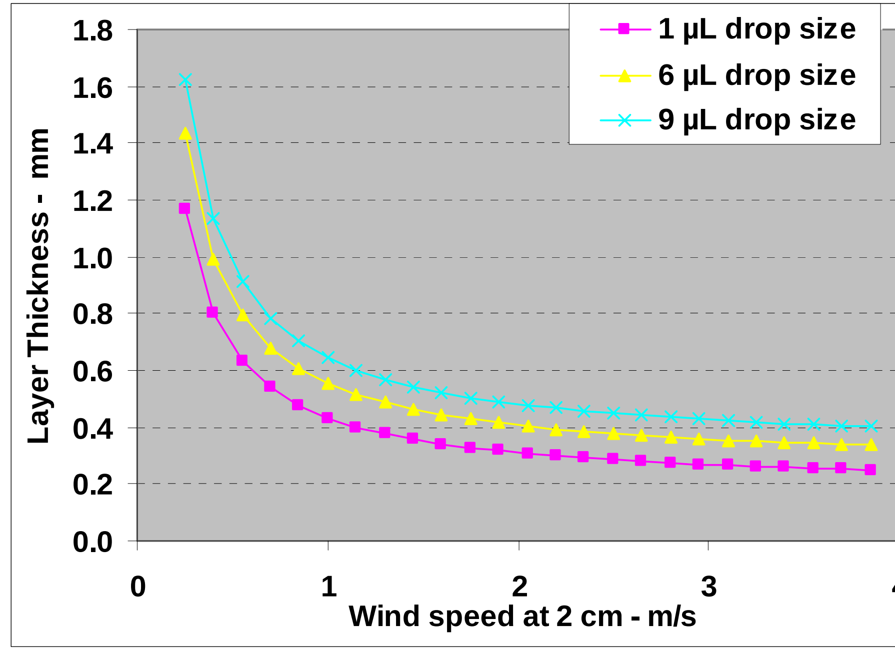
- ‘Effective average diffusion layer thickness’

assumed to depend on

- wind speed
- drop size

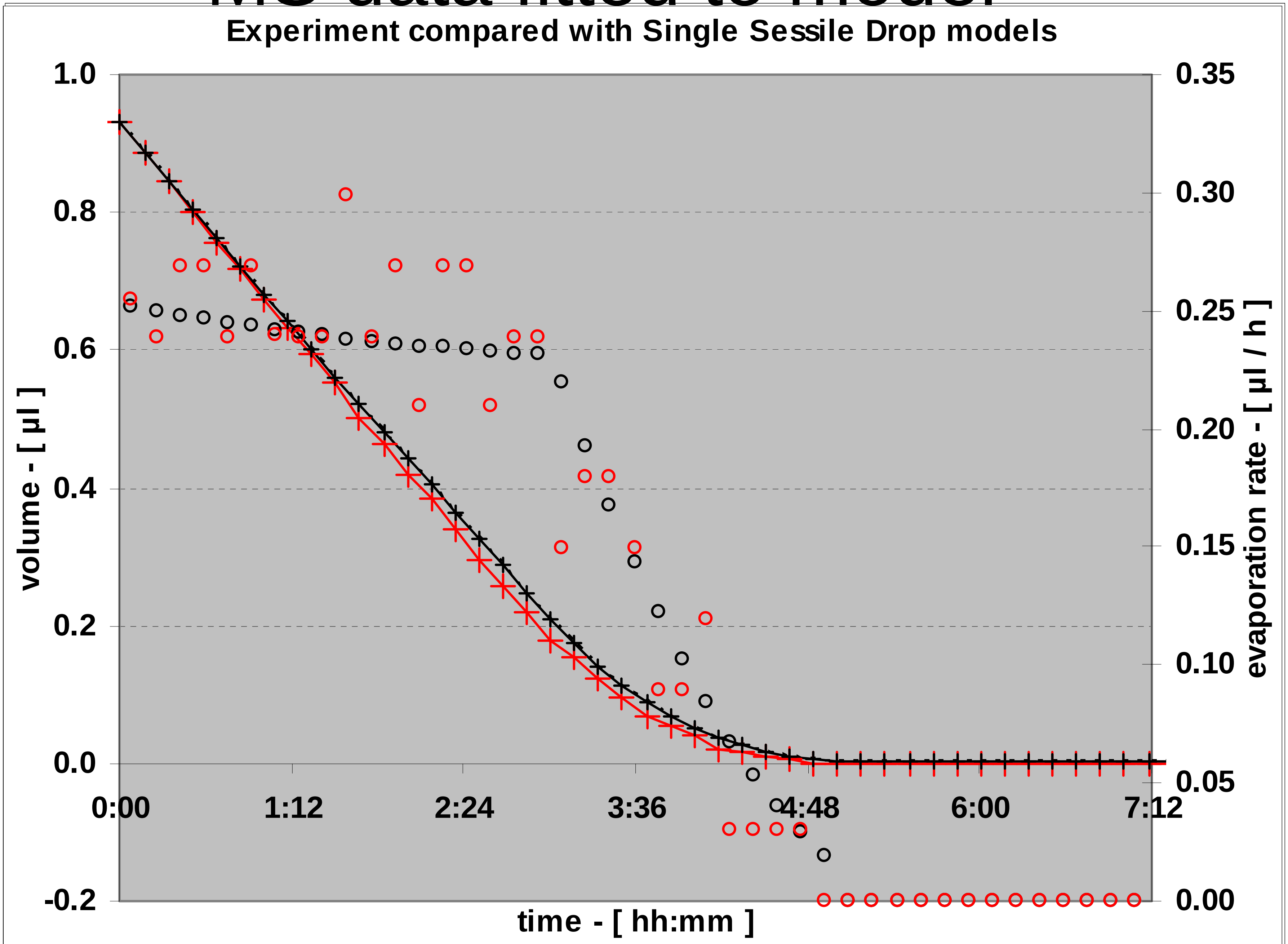
MS fit functions



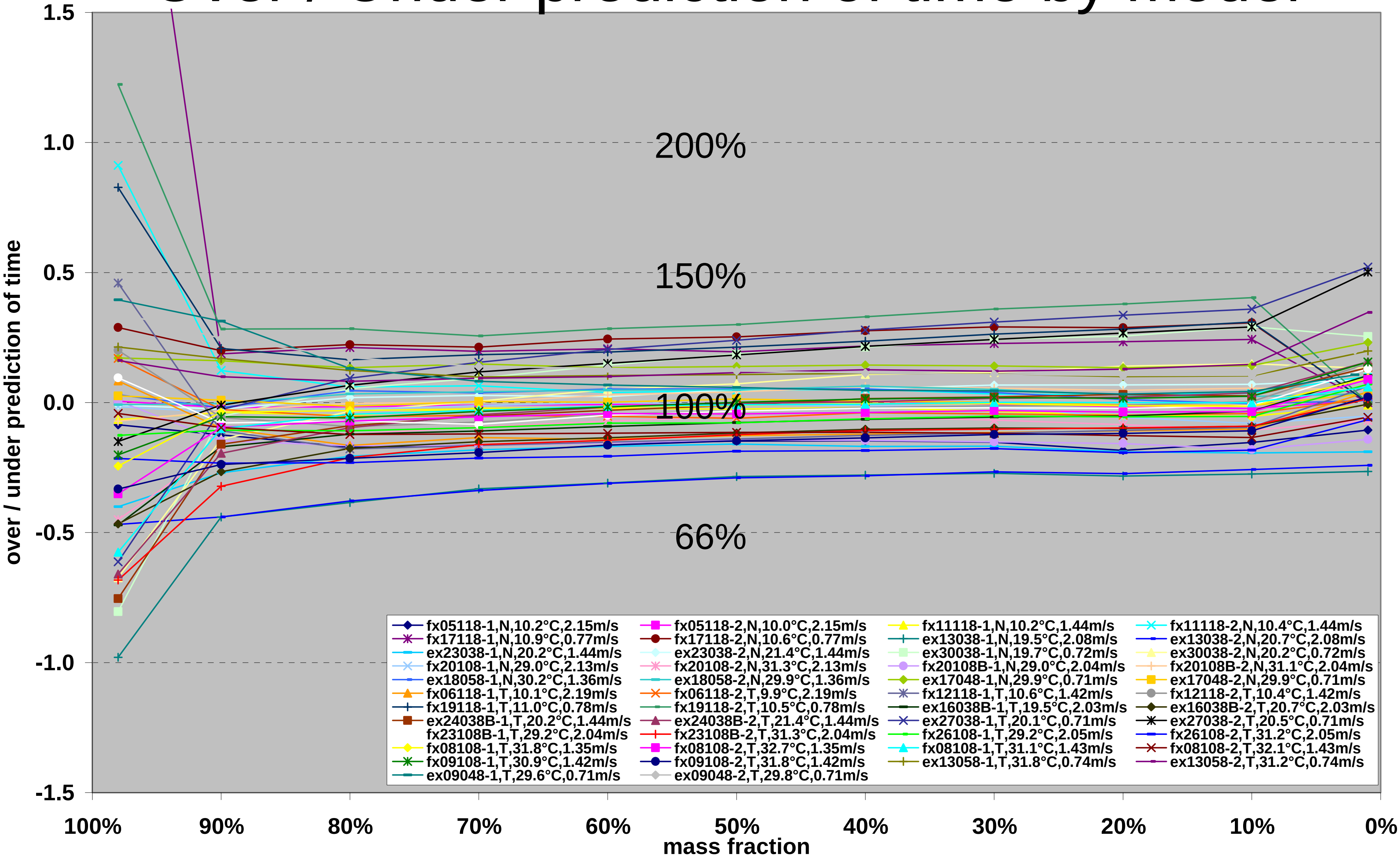


- Temperature
  - Exponential
- Relative Humidity
  - Exponential
- Wind Speed
  - Inverse with offset
- Drop Size
  - Exponential

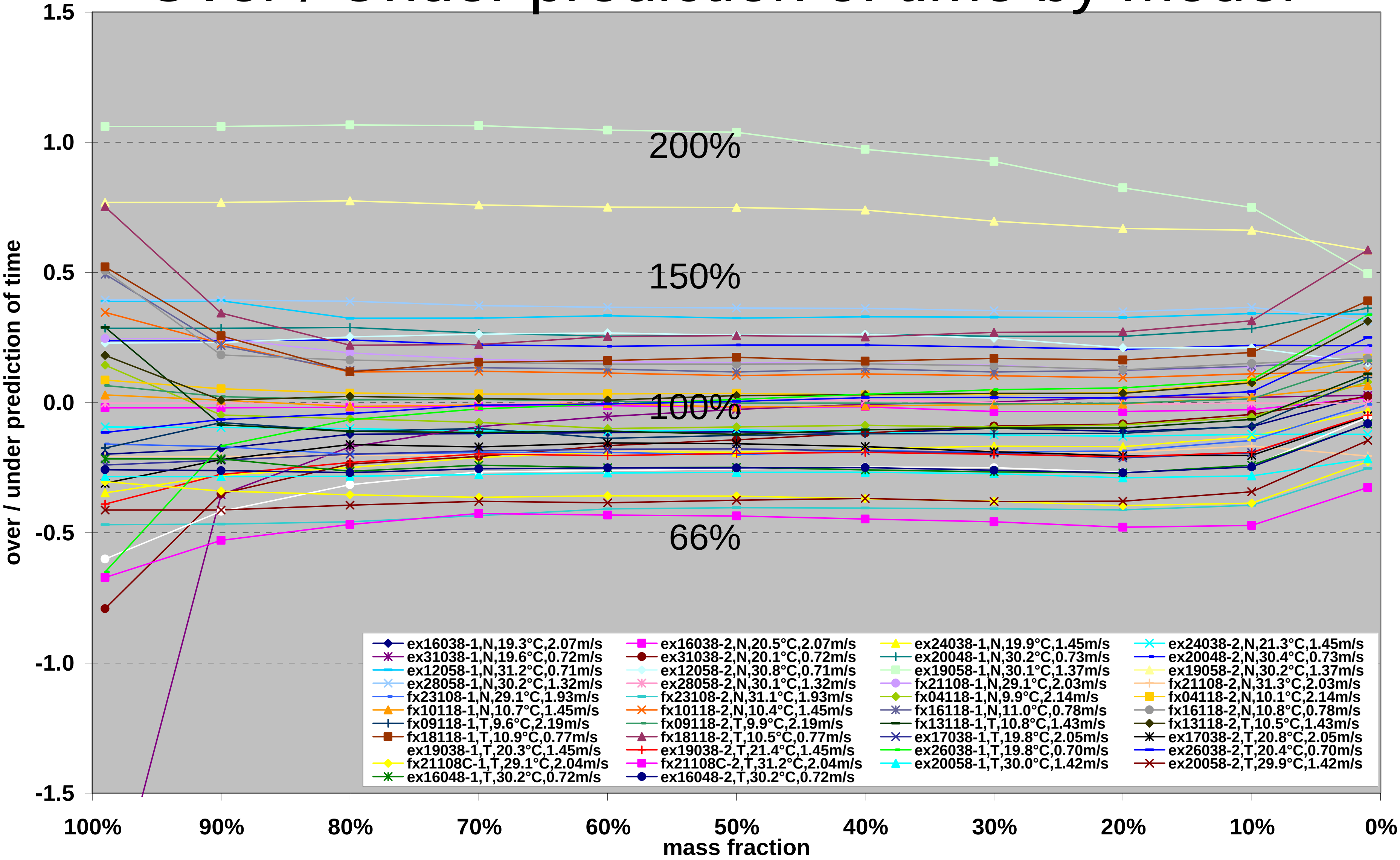
MS data fitted to model



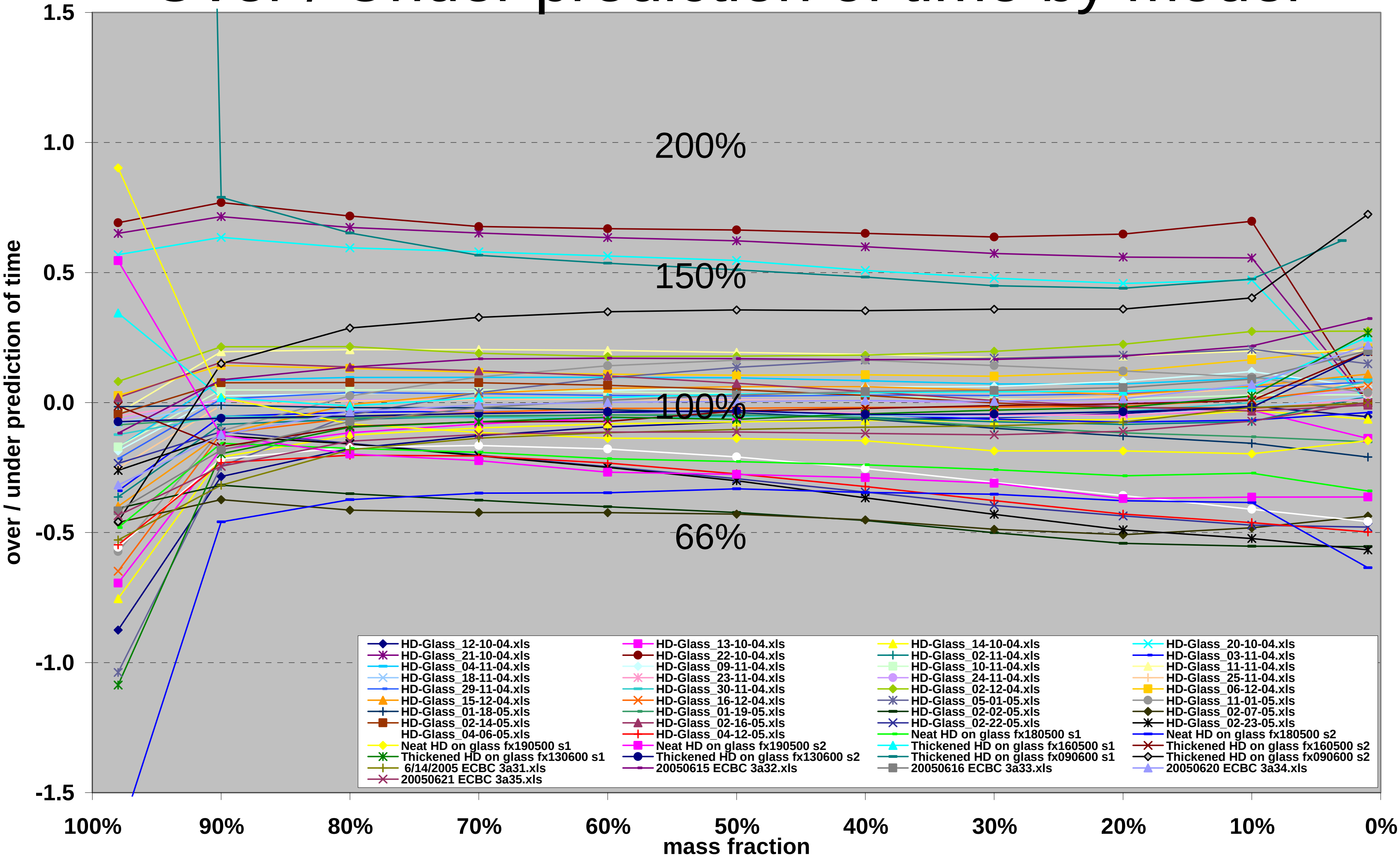
MS on Glass
Over / Under prediction of time by model



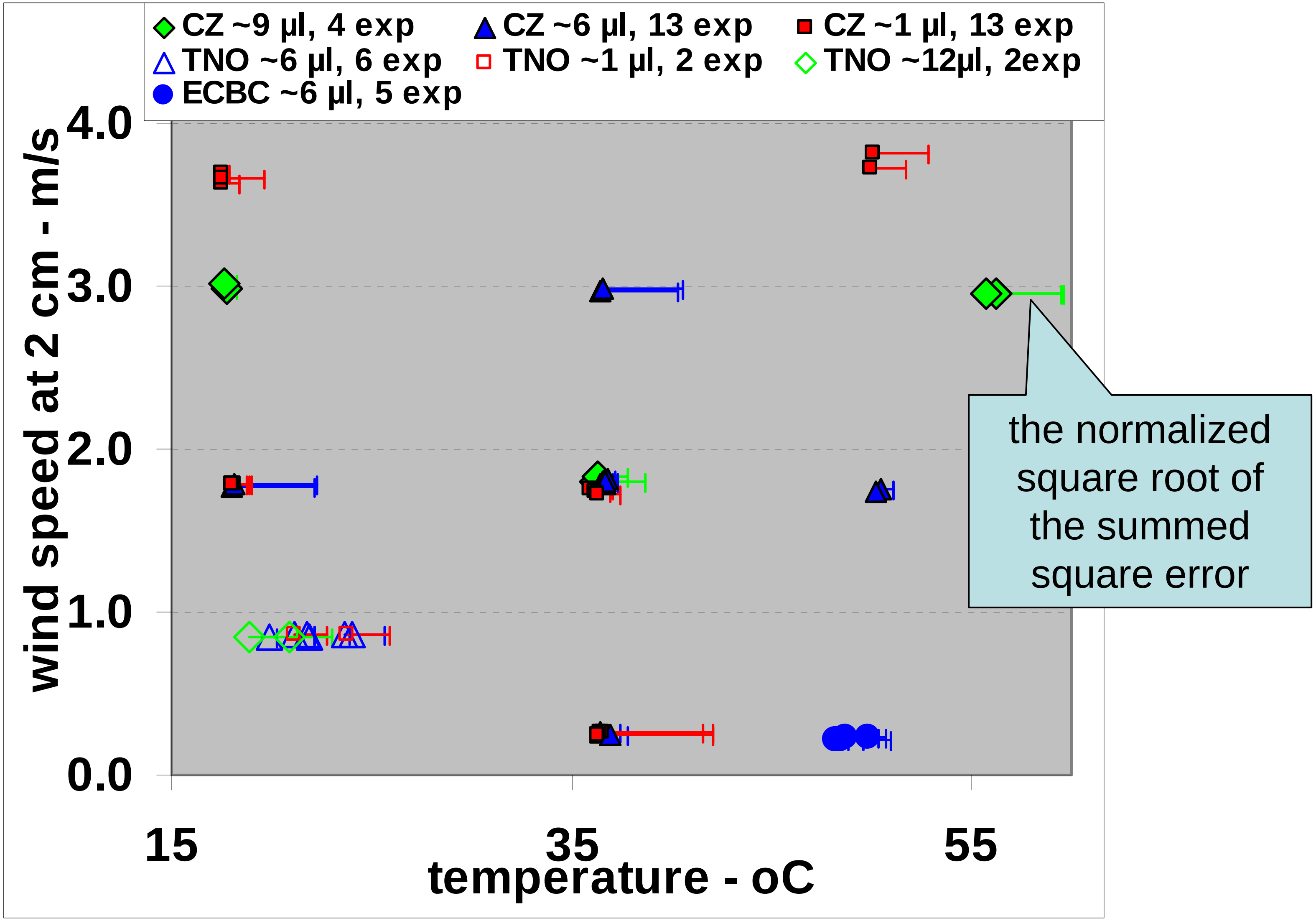
DEM on Glass
Over / Under prediction of time by model



HD on Glass
Over / Under prediction of time by model



Data space and Fit Quality's HD on Glass

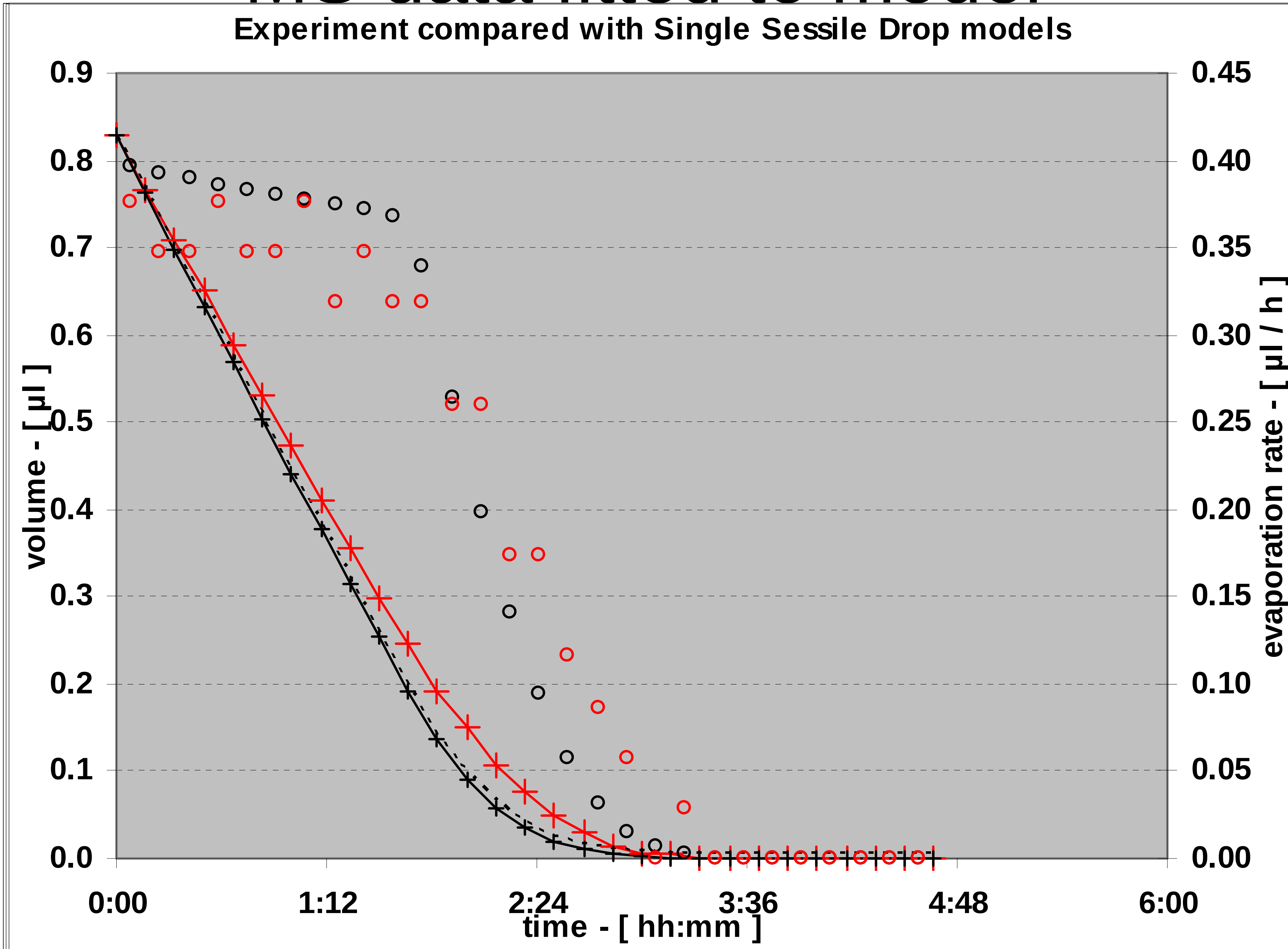


Conclusion

- Semi–Empirical Sessile Drop model
  - Fits existing data fairly well
    - Persistence times typically within 66% to 150% of experiment
  - Work in progress
    - More sessile drop data
    - Experimental Contact angle functions
    - Reactivity not tested yet

- Semi–Empirical Absorbed drop model
  - Prototype exists, Awaiting data

MS data fitted to model



Reliable Discrimination of High Explosive and Chemical / Biological Artillery Using Acoustic Sensors

US Army RDECOM-ARDEC

By: Myron E. Hohil, Sachi Desai, and Amir Morcos

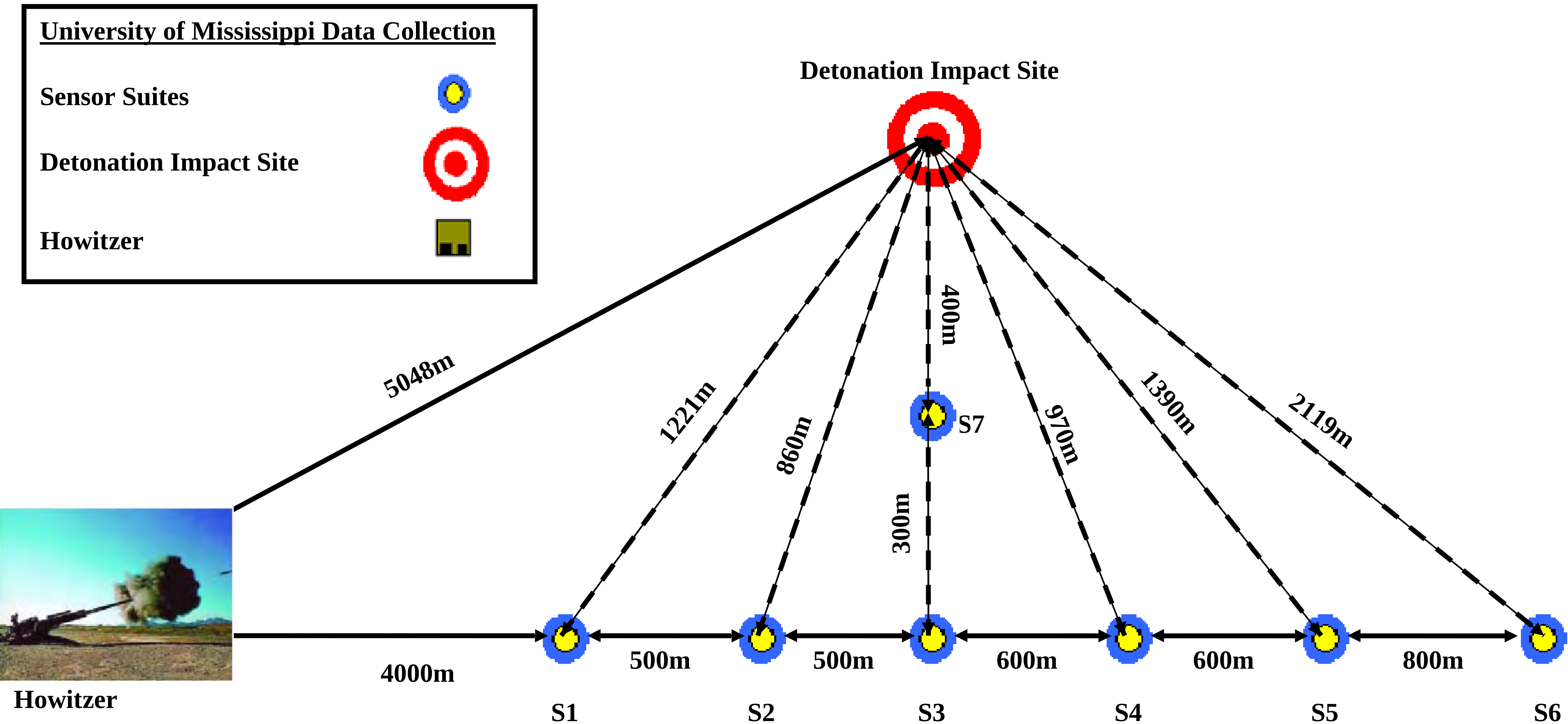
Chemical and Biological Weapon Threats and Needs

- Determining if an incoming artillery round contains High Explosive material or Chemical/Biological agent on the battlefield.
- Providing field commanders with greater response time using a stand alone acoustic sensor.
- Giving greater situational awareness to threatened soldiers.

Acoustic Signature Data Collection of Blast Events

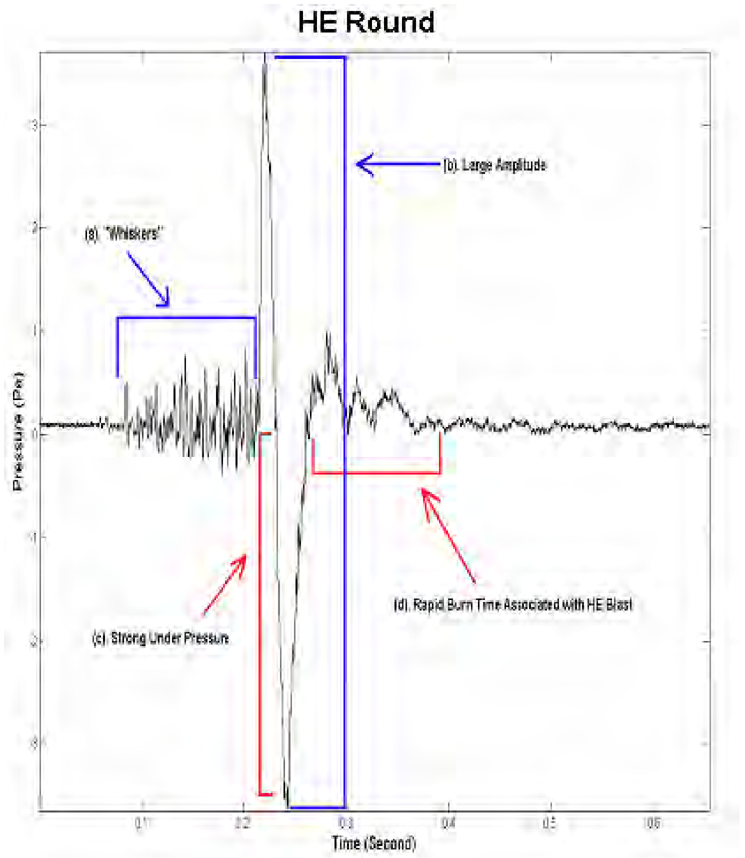
- Yuma Proving Ground Data Collection.
  - Conducted by National Center of Physical Acoustics (NCPA) in cooperation with ARDEC.
  - 39, rounds fired.
  - 3 categories of rounds were used, HE, Type A CB, and Type B.
- Dugway Proving Grounds Data Collection.
  - Conducted by DPG Team and U.S. Army Edgewood Chemical Biological Center (ECBC) .
  - 265, rounds fired.
  - 2 categories of rounds were used, HE and Type A CB.

Yuma Proving Ground (YPG) Test Layout



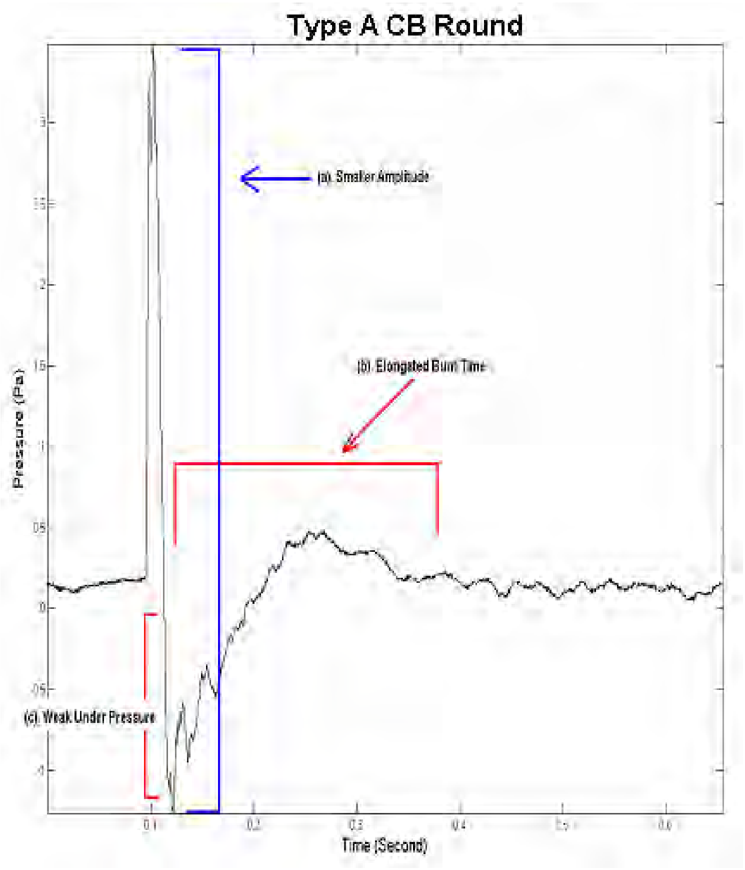
Typical Blast of HE Round

- High frequency precursors to the main blast.
  - Generated by Supersonic Shrapnel Elements.
- Large Amplitude of Main Blast.
- Large under pressure element .
  - Generated by large comparable weight of explosives rapidly burning.
- Short Duration Signatures.



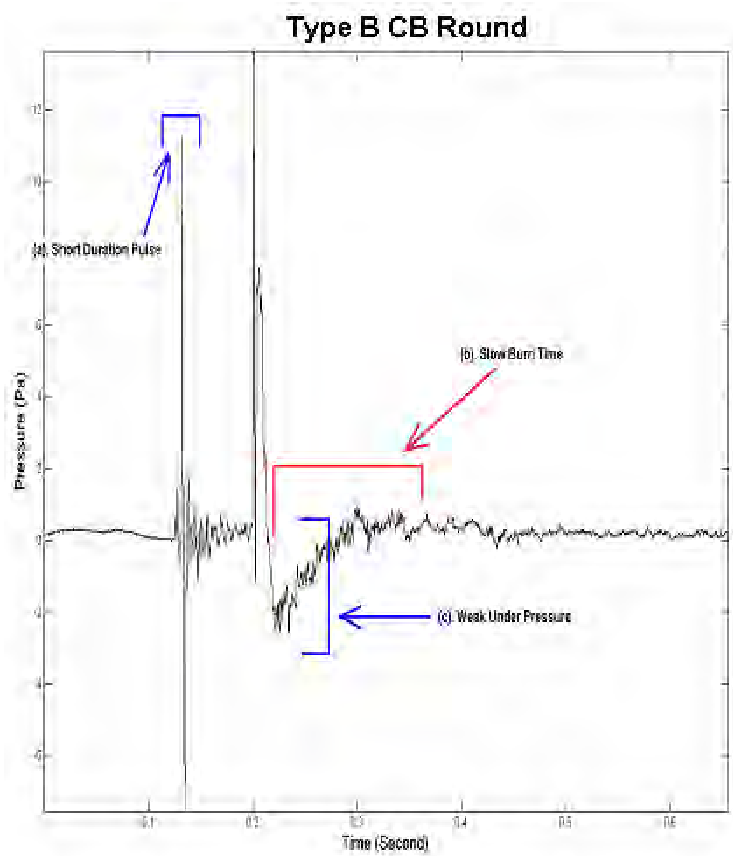
Typical Blast of Type A CB Round

- Small amplitude associated with main blast.
  - The explosive material is minimal compared to the comparable HE round type.
- Elongated burn time following main blast.
  - The deliberately slow to properly release the compounds.
- Weak under pressure.



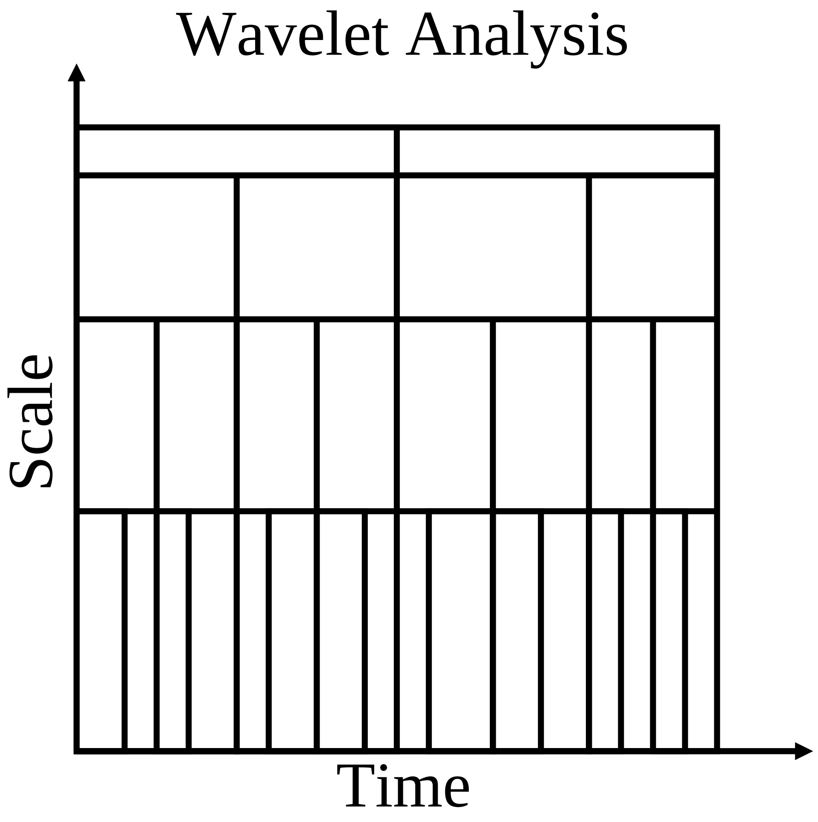
Typical Blast of Type B CB Round

- Short Duration Pulse.
  - Resulting from base ejection rounds.
- Weak Under Pressure.
  - Small amount of Explosives.
- Slow Burn Time.
  - Elongated to properly discharge contents of the round.



Wavelets

- Efficiently represent non-stationary, transient, and oscillatory signals.
- Desirable localization properties in both time and frequency that has appropriate decay in both properties.
- Provide a scalable time-frequency representation of artillery blast signature.



Discrete Wavelet Transform (DWT)

- Derived from subband filters and multiresolution decomposition.
  - Coarser Approximation.
  - Removing high frequency detail at each level of decomposition.
- Acts like a multiresolution transform.
  - Maps low frequency approximation in coarse subspace high frequency elements in a separate subspace.

Defining Parameters

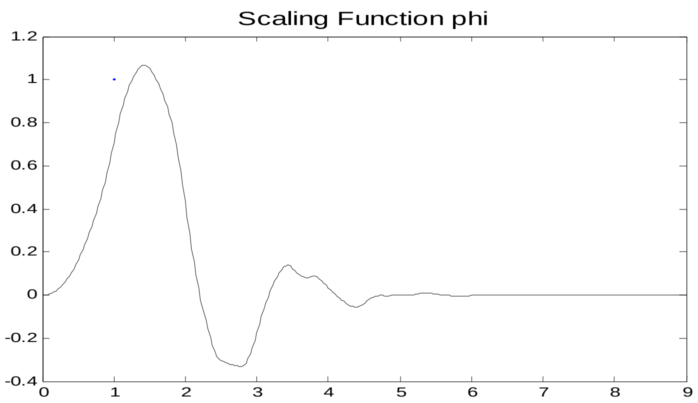
Scaling Function

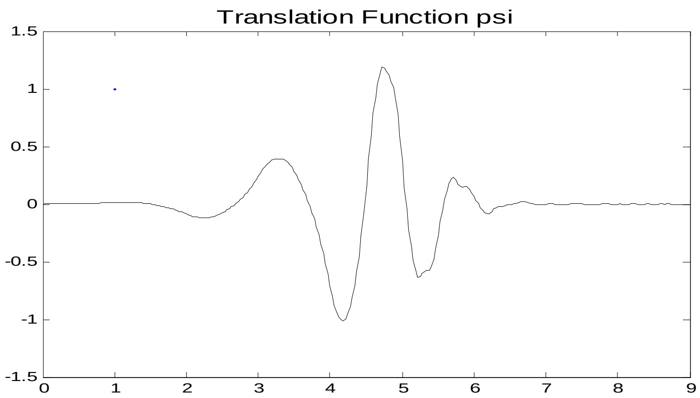
$$\phi(x) = 2^{1/2} \sum_{k=0}^{L-1} h_{k+1} \phi(2x - k)$$

Wavelet Function

$$\psi(x) = 2^{1/2} \sum_{k=0}^{L-1} g_{k+1} \phi(2x - k)$$

Daubechies Wavelet n = 5

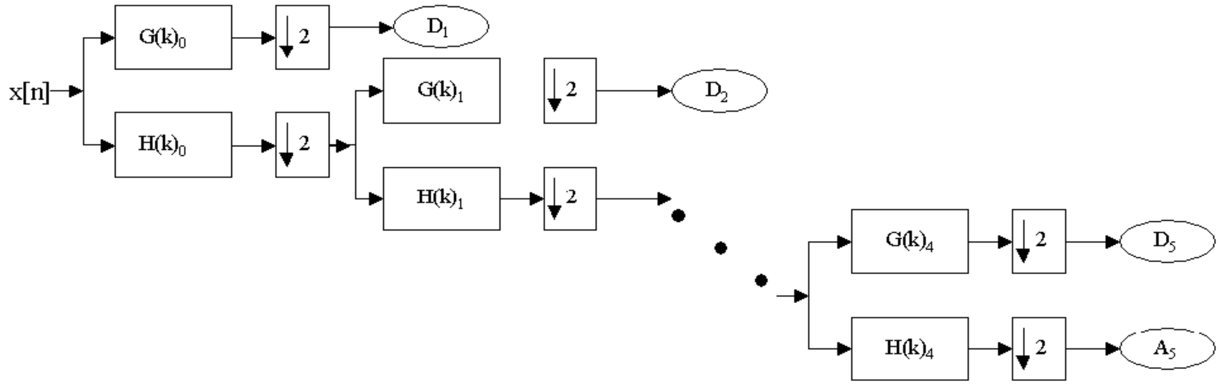




- Representation of the scaling and translation function of db5.
  - Scaling function resembles blast signature of the HE and CB rounds.
  - Provides the ability to approximate signal with the characteristic wavelet.

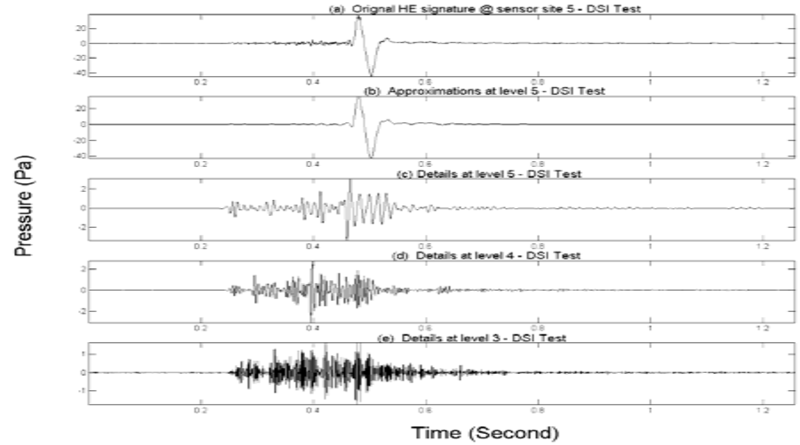
Multiresolutional Analysis

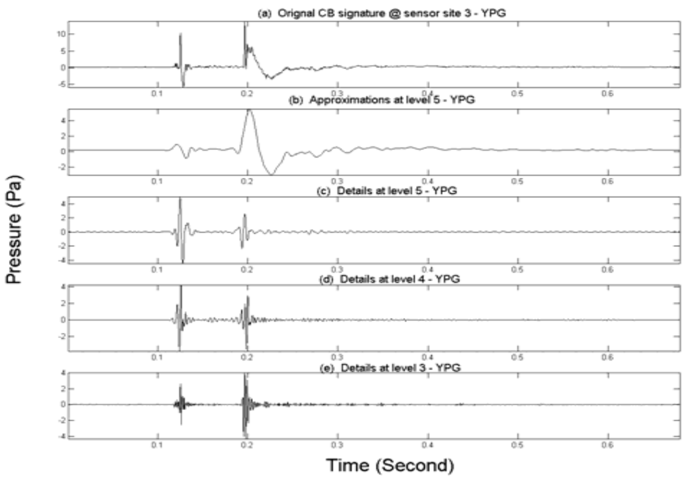
- Using a series of successive high pass and low pass filters to create a set of subspaces.
  - High pass filter obtains the details of the signatures while the low pass filter obtains a coarse approximation of the signal.
- The resulting banks of dyadic multirate filters separate the frequency components into different subbands.
  - Each pass through gives you resolution of factor 2.

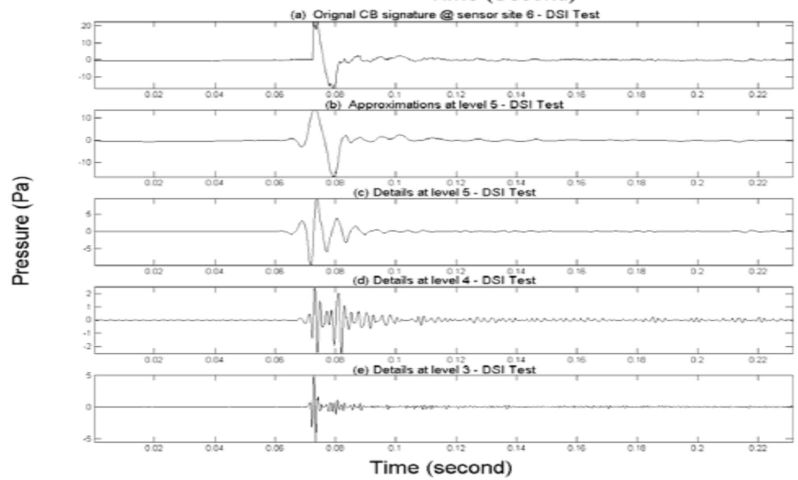


Effects of Wavelet Decomposition

- Wavelet decomposition to level 5 of three varying blast types from varying ranges.



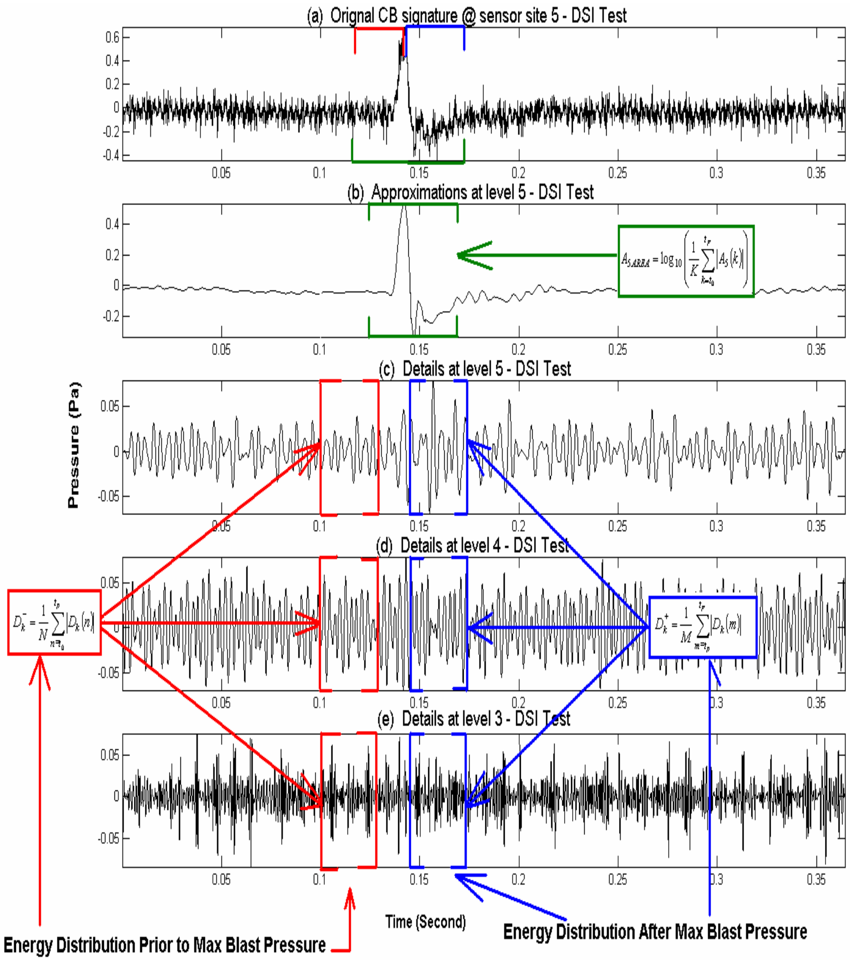


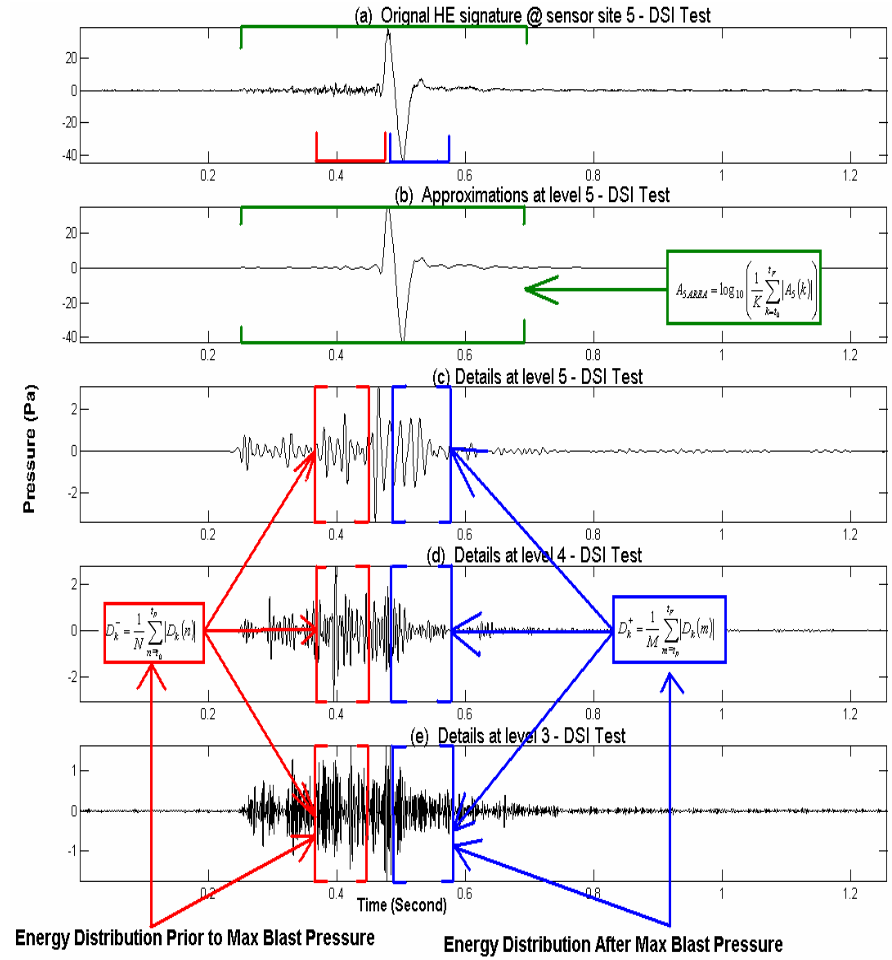


Wavelet Extracted Features

- Comprised of primitives derived from the normalized energy distributions within the details at level 5, 4, and 3 of the wavelet decomposition.
- Distribution of blast type differ greatly when taken prior to the max pressure, $D_k^- = \frac{1}{N}\sum_{n=t_0}^{t_P} |D_k(n)|$, with respect to distribution after the max blast, $D_k^+ = \frac{1}{M}\sum_{m=t_P}^{t_F} |D_k(m)|$.
- Resulting Ratio. $x_{Dk} = \log_{10}\left(\frac{D_k^-}{D_k^+}\right)$
- A5 area is a feature derived from wavelet coefficients at level 5.
- Integrating the magnitude of the area for the coefficients between the start and stop times.
- $$A_{5AREA} = \log_{10}\left(\frac{1}{K}\sum_{k=t_0}^{t_F} |A_5(k)|\right)$$

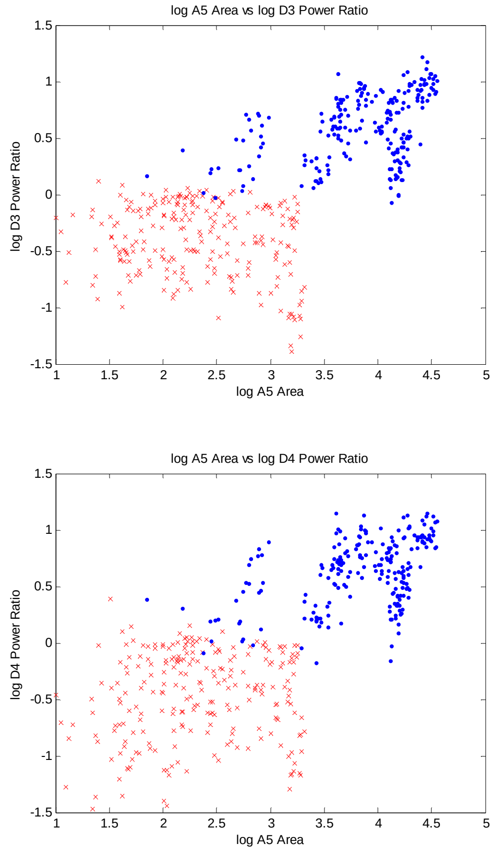
Extracted Features Using DWT



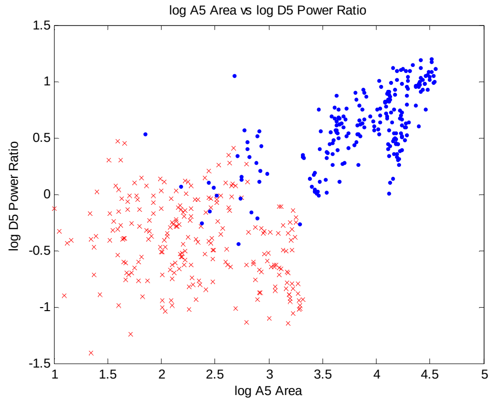


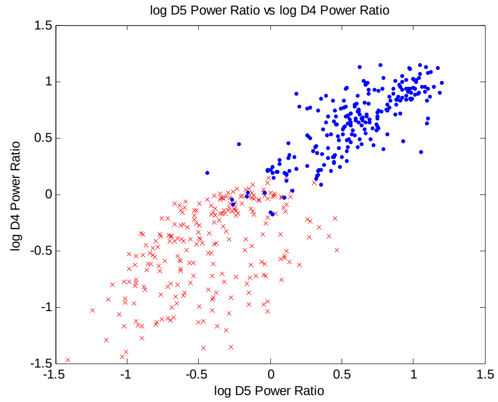
4-tuple Feature Space

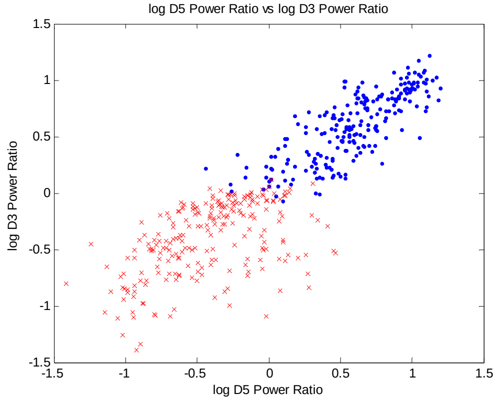
- This energy ratio leads to the discover of 4 features with A5 area that are not amplitude dependent.
- Our n-tuple feature space thus becomes a 4-tuple space, $x^p = \left[x^P_{D5}, x^P_{D4}, x^P_{D3}, A^P_{5AREA}\right]$, to be applied for classification.

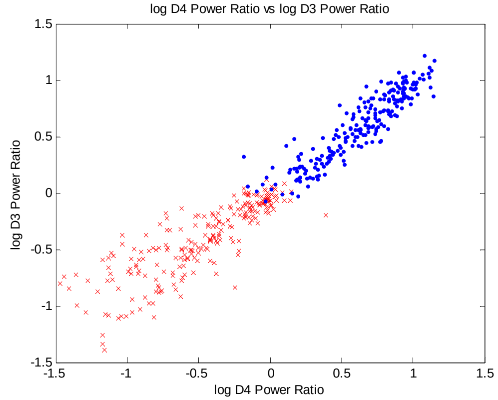


2-D Feature Space Realization



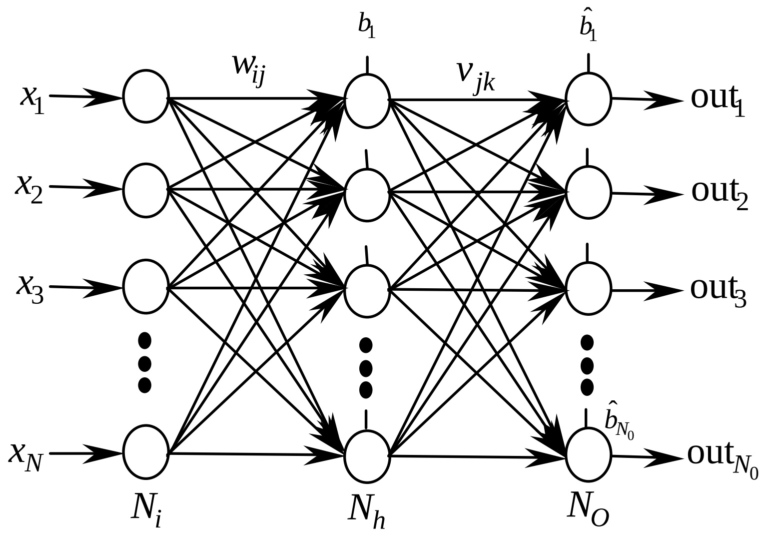






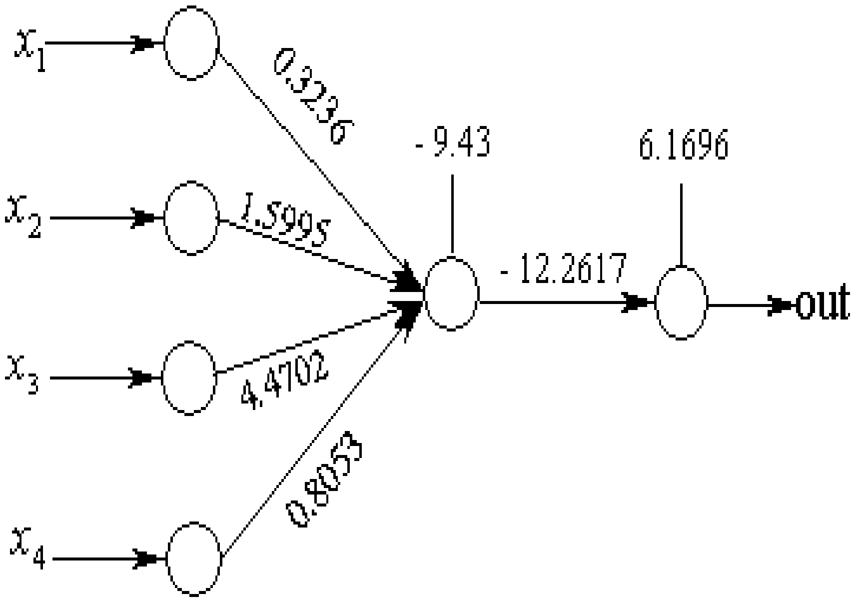
Neural Network

- Realize non-linear discriminant functions and complex decision regions to ensure separability between classes.
- Standard Multilayer Feedforward Neural Network.
- Number of hidden layer neurons depend on complexity of required mapping.



Results of Training Neural Network to DSI Data

- Feature Space created using DWT.
  - 4-tuple feature vector.
  - $x^p = \left[x^P_{D5}, x^P_{D4}, x^P_{D3}, A^P_{5AREA} \right]$
  - 22 randomly selected vectors from 461 signatures.
- Trained Neural Network to trained output data of 0.
  - Single hidden layer neuron.
  - Total error in equation after training is less then 5e-3.
  - Learning rate of 0.1.



Results of HE/CB Discrimination

- Experiment 1.
  - Applying a neural network with the weights in the table 1 to DPG data, 99.1% Correct Classification.
- Experiment 2.
  - A neural network containing 4 hidden layer neurons trained using entire DPG dataset tested against NCPA dataset, 96.9% Correct Classification.

w_{i1}	w_{i2}	w_{i3}	w_{i4}	v_{j1}
11.6967	0.5343	-0.4958	-2.4991	-13.4966
4.6377	1.2455	3.5569	5.3068	13.3761
4.7023	0.9875	7.3951	8.902	-15.3761
-5.2246	1.481	2.6982	4.1203	-19.6513
-2.8169	1.4847	-18.9732	-23.6088	-14.286

Experiment #	Training Data	Test Data	Classification	Percentage
1	11 CB (DSI)	225 CB (DSI)	225 CB / 0 HE	100%
	11 HE (DSI)	214 HE (DSI)	210 HE / 4 CB	98.10%
2	236 CB (DSI)	166 CB (YPG)	165 CB / 1 HE	99.40%
	225 HE (DSI)	57 HE (YPG)	51 HE / 6 CB	89.50%

Blind Results of HE/CB discrimination

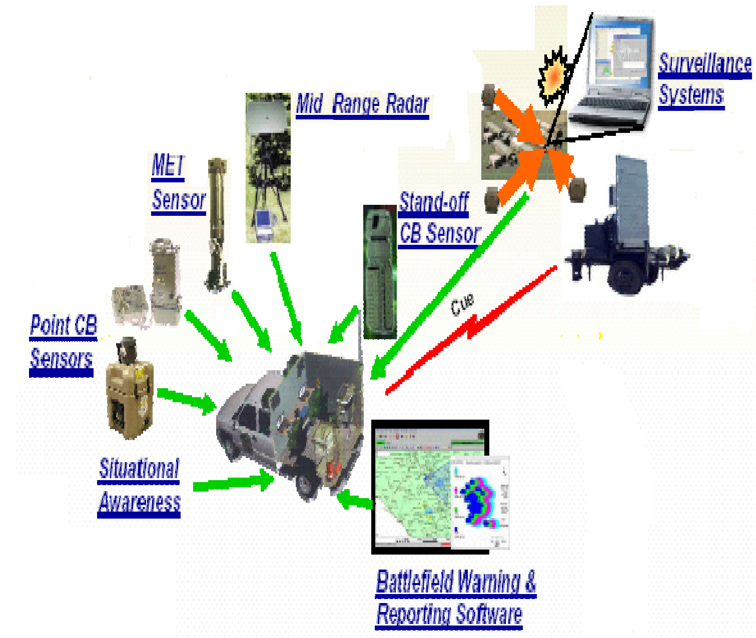
- Experiment 3.
  - Utilizing the neural network containing 4 hidden layers neurons trained against the entire “known” DPG data set was then tested against the “blind data” the results once compared with the truth resulted in 98.3% and 95.7% reliable classification.

w_{i1}	w_{i2}	w_{i3}	w_{i4}	v_{j1}
11.6967	0.5343	-0.4958	-2.4991	-13.4966
4.6377	1.2455	3.5569	5.3068	13.3761
4.7023	0.9875	7.3951	8.902	-15.3761
-5.2246	1.481	2.6982	4.1203	-19.6513
-2.8169	1.4847	-18.9732	-23.6088	-14.286

Experiment #	Training Data	Test Data	Classification	Percentage
3	236 CB (Blind)	230 CB (Blind)	226 CB / 4 HE	98.3 %
	225 HE (Blind)	184 HE (Blind)	176 HE / 8 CB	95.7 %

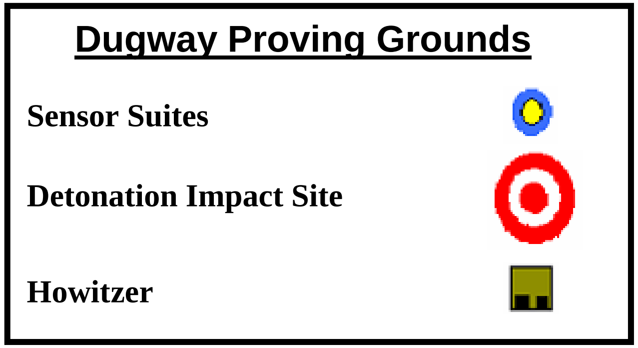
Experiment 4 Real Time Implementation

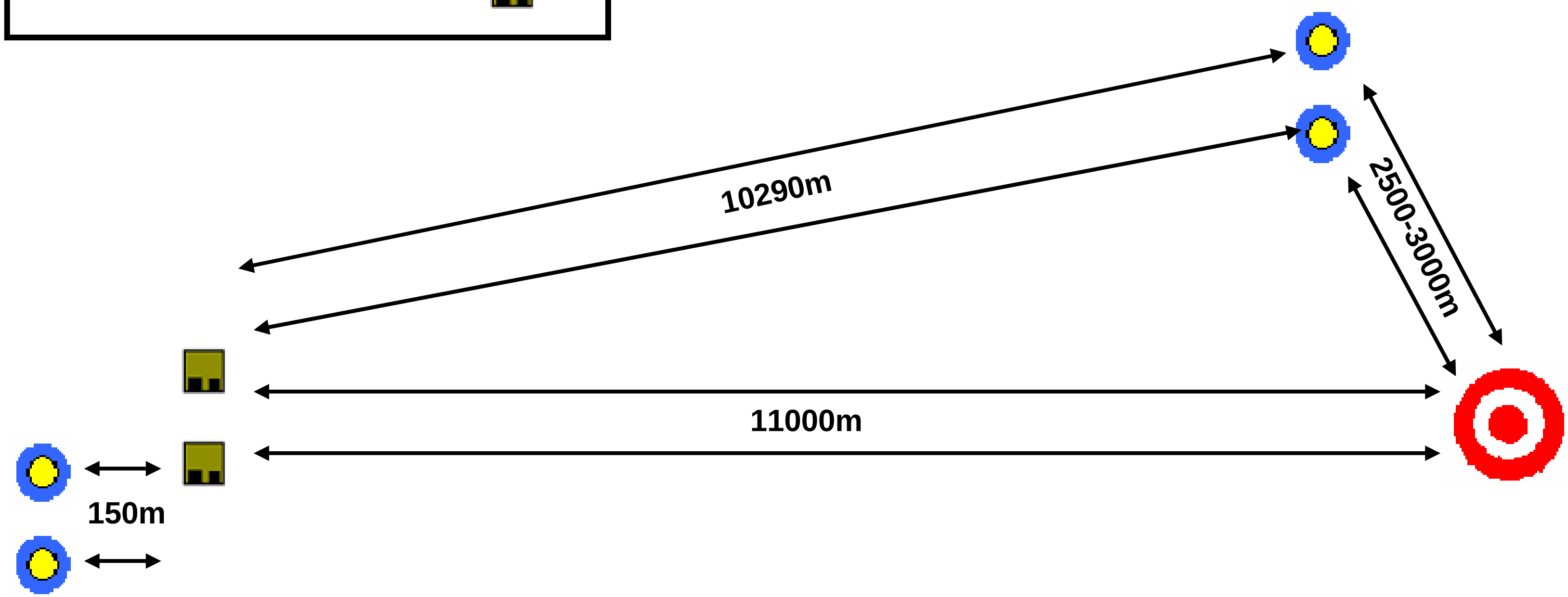
- Portable Area Warning Surveillance System (PAWSS).
  - 1yr Limited Objective Experiment (LOE).
  - Focused on the utility of cascading detection methodologies.
  - Combines Stand-off CBRN systems to address both force/installation protection.
- LOE Outcomes.
  - Operable Products leading to fully designed products that are sustainable.
  - Demonstration of capabilities within simulated battlefield environments of layered wide area cascading detection.



PAWSS LOE Test Layout

Artillery Variant	# of Rounds
HE	24
CB	48





PAWSS LOE Results

- June 19th-28th Portable Area Warning Surveillance System (PAWSS) Limited Objective Experiment (LOE).
- Implemented real time version of CBRN Discrimination at PAWSS LOE conducted by ECBC.
- 100% single volley discrimination, never tested against dual volley, still 83%, also all event starts were detected for 100%.
- Assist in transition and support of acoustic element CBRNEWS ATD extending LOE efforts.

Event Type	# of Events	Discriminated Correctly
Single Round	38	38/38; 100%
Dual Round	34	28/34; 83%

Real Time Performance

- During June 21st and June 22nd, 2005 a proof of concept test was conducted for the acoustic CBRN discrimination algorithm.
  - PAWSS Test Site, DPG.
    - Acoustic System 2.5km-3km from Impact Zone.
  - A C++, real time algorithm was tested at DPG as part of the acoustic portion of PAWSS LOE conducted by JPM for NBC Contamination Avoidance at ECBC.
  - A total of 72 HE/CB rounds were detonated.
    - A howitzer fired 24 HE, and 48 CB rounds.
- Single Round Volley Results.
  - 38 Airburst Detonation (14 HE, 24 CB), 100% Correct Classification.
- Multiple Round Volley.
  - CBRN Algorithm Never Benchmarked in Lab vs. Multiple Rounds.
    - 2 Rounds simultaneously fired followed by a 3rd round fired soon as possible.
  - 34 Airburst Detonation (10 HE, 24 CB).
    - 17 events, each event consisted of 2 detonations.
  - 83% Overall Correct Discrimination of HE/CB.
    - 100% discrimination on all HE rounds.
    - 100% acoustic detection of all events.
    - 28 correctly discriminated from 34 detonations.
    - Shortcomings occur within the data acquisition process, limited by processing window size.

Conclusion

- Features extracted facilitate robust classification.
  - Reliable discrimination of CB rounds, 98.3% or greater of single volley events.
- The features this algorithm is based on go beyond previous amplitude dependent features.
  - Degradation due to signal attenuation and distortion is nullified and exceeds 3km in range propagation.
- Scalable time frequency representation uncovered non-readily detectable features.
  - Subband components remove higher frequency noise features.
  - Isolating the details of higher oscillatory components.
- Real time verification at PAWSS LOE of CBRN Discrimination Program Implemented in C++.
  - Single volley round discrimination in real time for all variants was 100%.
  - Dual volley round discrimination in real time for all variants was 83%, and detected an event 100% of the time.
- Wavelets can be possibly used to discriminate varying types of artillery projectile launches from impacts independent of range.
  - Utilizing wavelets and other signal processing techniques to perform a similar task as described within with refinement for the problem.
- Future Considerations.
  - Networking of sensors can provide TDOA abilities to further localize a threat.

Acknowledgements

- Chris Reiff from Army Research Lab for his assistance in providing data sets from the DSI test.
- David Sickenberger and Amnon Birenzvige at Edgewood Chemical and Biological Center (ECBC) providing detailed documentation about the test at DSI.
- Edward Conley at ECBC allowing us to participate in the PAWSS LOE.

Allocation of Resources in CB Defense: Optimization and Ranking

by

NMSU: J. Cowie, H. Dang, B. Li
Hung T. Nguyen
UNM: F. Gilfeather

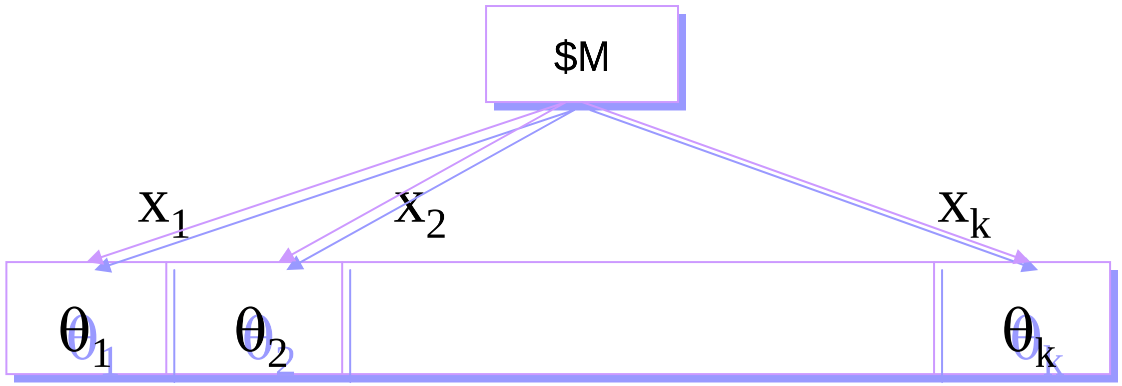
Oct 26, 2005

Outline

- Problem Formulation
- Architecture of Decision System
- Optimization Methods
- Ranking Procedures
- Conclusions and Future Work

Problem Formulation

Given \$M, let $\theta=(\theta_1,\ldots,\theta_k)$ be the mitigating variable of some asset, find "optimal" allocations $(x_1,\ldots,x_k)$ to $(\theta_1,\ldots,\theta_k)$ to minimize consequences $c=(c_1,\ldots,c_k)$ of an CB attack to the asset, and rank these allocations according to various possible "preferences" of decision-makers.



$$\sum_{i=1}^{k} x_i = \$M$$

Problem Formulation

Example:

Asset: An airbase

Money: $M=1million

Defense Measures:

θ_1: chemical agent detector
θ_2: biological agent detector
θ_3: perimeter protection
θ_4: trained onsite personnel
θ_5: chemical prophylaxis
θ_6: biological prophylaxis
θ_7: medical treatment

Consequences:

c_1: number of casualties
c_2:cost of remediation
c_3:number of days of operation disruption
c_4:negative geo-political impacts

Problem Formulation

- *Optimal Allocations*

We need to formulate an "objective function".

$\varphi : \Omega \to \Psi$, where

$$\Omega = \{(x_1, \cdots, x_k) : \sum_{i=1}^{k} x_i = M\} \subseteq R^k$$

$$\Psi = \{c = (c_1, \cdots, c_m)\} \subseteq R^m$$

Ω is the space of allocations,

Ψ is the space of consequences.

The optimization problem is **Min $\varphi(x_1,\ldots,x_k)$** subject to $(x_1, \cdots, x_k) \in \Omega$, which is an optimization problem with multiple objectives. In principle, the problem can be solved by standard techniques using decision-makers' preferences and value trade offs.

Problem Formulation

- *How to obtain the objective function* $\varphi : R^k \to R^m$?

$$X = (x_1, \cdots, x_k) \to \Delta\theta = (\Delta\theta_1, \cdots, \Delta\theta_k) \to c(\Delta\theta) = (c_1(\Delta\theta), \cdots, c_m(\Delta\theta))$$

The relation between $X=(x_1,\ldots,x_k)$ and the consequence $\varphi(X)$ is:

a) $c(\theta)$: the consequence c is a function of θ.

(Data/Scenarios from experts).

b) $\theta(X)$: is a function of X. (Cost model).

So,

$$\varphi(X) = c \circ \theta(X)$$

Problem Formulation

Example 1: An Example of Objective Function

$$c_i(X) = \alpha \sum_{s=1}^{p} \{ c_i^0(s) L(s) \prod_{j=1}^{k} [1 - e(s, \theta_j(X))] \}$$

Where:

*α is a normalization constant,
*p is the number of scenarios,
*$c^0_i(s)$ initial consequence before improvements for the s^{th} scenario,
*L(s) is a probability (sums to 1),
*$\theta_j(X)$ is the number of detectors of the i^{th} kind, it is a function of X.
*$e(s, \theta_j(X))$ is the effectivity of the i^{th} kind of defense measure on the scenario s.

Problem Formulation

Minimize $\quad f(x_1, x_2, \cdots, x_6) = \sum_{s=1}^{5} 10 \prod_{j=1}^{6} [1 - \frac{s}{5} \sin(\frac{x_j}{x} \pi)]$

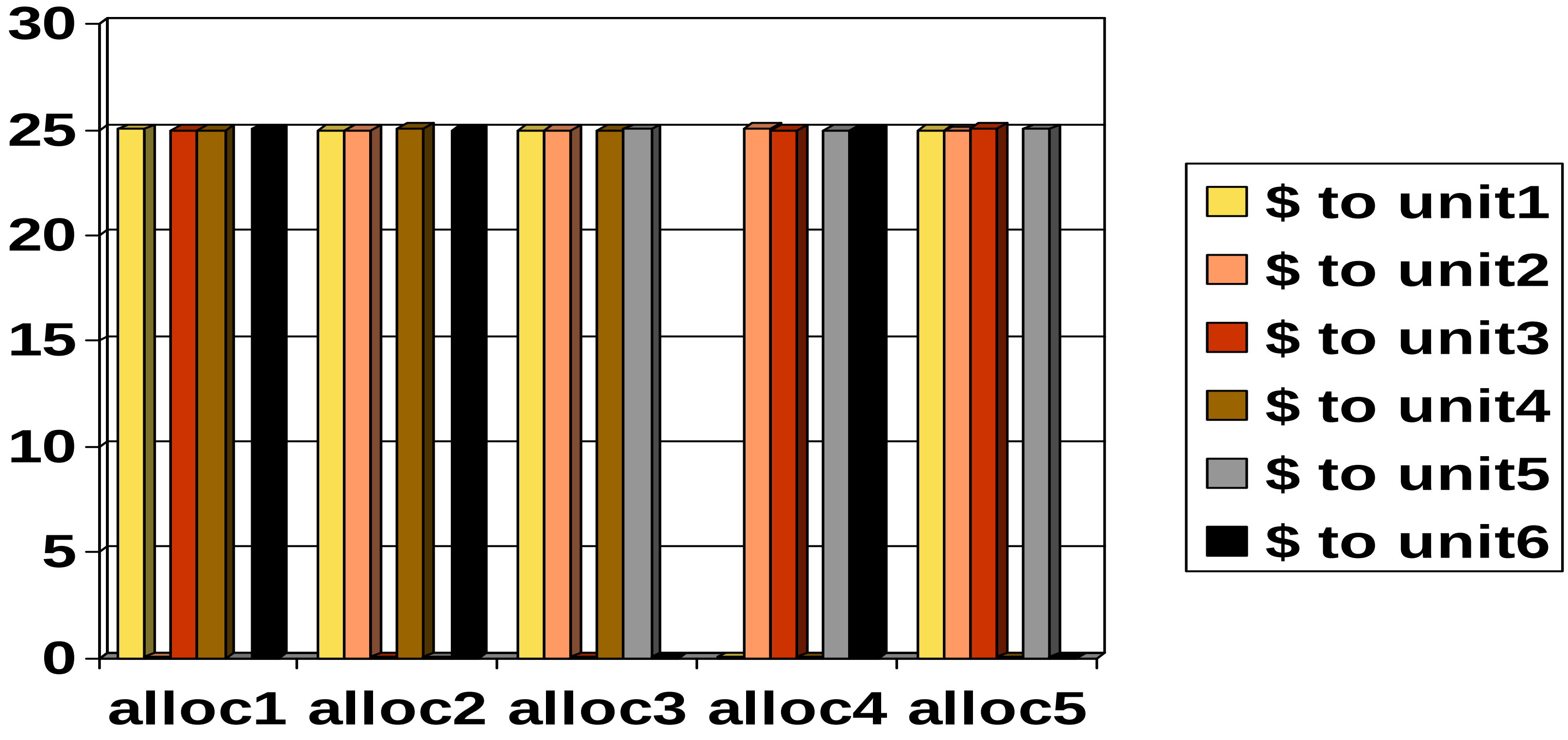
subject to $\quad \sum_{i=1}^{6} x_i = 100 \; , \; x_i \geq 0 \, .$

Using simulated annealing, we get:

$(x_1, x_2, \cdots, x_6)$	Minimum
(25.0077 0.0053 24.9808 24.9981 0.0004 25.0076)	9.6074
(24.9952 24.9950 0.0072 25.0397 0.0052 24.9578)	9.6074
(24.9629 24.9837 0.0278 24.9988 25.0181 0.0087)	9.6076
(0.0309 25.0083 24.9321 25.0111 25.0168 0.0007)	9.6075
(0.0366 25.0442 24.9996 0.0079 24.9497 24.9620)	9.6076
(24.9827 24.9416 25.0395 0.0117 25.0086 0.0160)	9.6075
(24.9924 25.0519 0.0210 0.0217 24.9539 24.9592)	9.6076

Problem Formulation

Histogram for optimal allocations (X=$100).



Problem Formulation

Component-wise optimization is not a proper solution for our multiple objective problem.

Example 2: Minimize $\varphi(x_1,\ldots,x_k)$ over a constrained set A with predetermined acceptable consequences levels.

$$A = \{(x_1,\cdots,x_k) : \sum_{i=1}^{k} x_i = M \text{ and } \varphi_j(x_1,\cdots,x_k) \le \hat{c}_j\}$$

Architecture

INPUT
- Data from scenario tree: mitigating variables θ's, likelihood, consequences …
- Total budget \$X
- Acceptable consequences $\widehat{C}$
- Cost model

→

ANALYTIC TOOLBOX

- Utility function C=φ(X)
- Human interface: questionnaire

OPTIMIZATION
Minimizes utility function C=φ(x) subject to:

$$\sum x \le X$$

and

$$C \le \widehat{C}$$

RANKING
Ranks allocations using Choquet Integral, AHP, Multi Objective Programming

→

OUTPUT

$$\begin{bmatrix} x_1^* \\ x_2^* \\ x_3^* \\ \vdots \\ x_k^* \end{bmatrix} \begin{bmatrix} c_1^* \\ c_2^* \\ \vdots \\ c_m^* \end{bmatrix}$$

Optimization

1. Optimization of the problem in Example 2.

Minimize total cost $M = \sum_{i=1}^{k} w_i \Delta\theta_i$ subject to $c_j - \sum_{i=1}^{k} e_{ij} \Delta\theta_i \le \hat{c}_j$ for j=1,…,m, where

*k is the number of defense measures (mitigating variables)
*w_i is the cost of improving θ_i by one unit
*$\Delta\theta_i$ is the improvement in defense measure facilities θ_i
*c_j is the j^{th} consequence component in the initial variant (data)
*e_{ij} is the decrease in the result c_j of a scenario attack if we increase θ_i by one
*m is the number of components of a consequence vector after an attack

Optimization

Let $[w_1,\ldots,w_5]=[3,5,17,27,6]$, $c=[1000,100,60,20]$,

$\hat{c}=[200,50,29,13]$, and

$$(e_{ij}) = \begin{bmatrix} 40 & 4 & 3 & 1 \\ 48 & 3 & 2 & 2 \\ 55 & 6 & 3 & .4 \\ 80 & 5 & 4 & 3 \\ 66 & 4 & 4 & 2 \end{bmatrix} \qquad \Delta\theta = \begin{bmatrix} \Delta\theta_1 \\ \Delta\theta_2 \\ \Delta\theta_3 \\ \Delta\theta_4 \\ \Delta\theta_5 \end{bmatrix}$$

We want to find $\Delta\theta_i$'s such that $M=\sum_{i=1}^{k} w_i \Delta\theta_i$ is minimized.

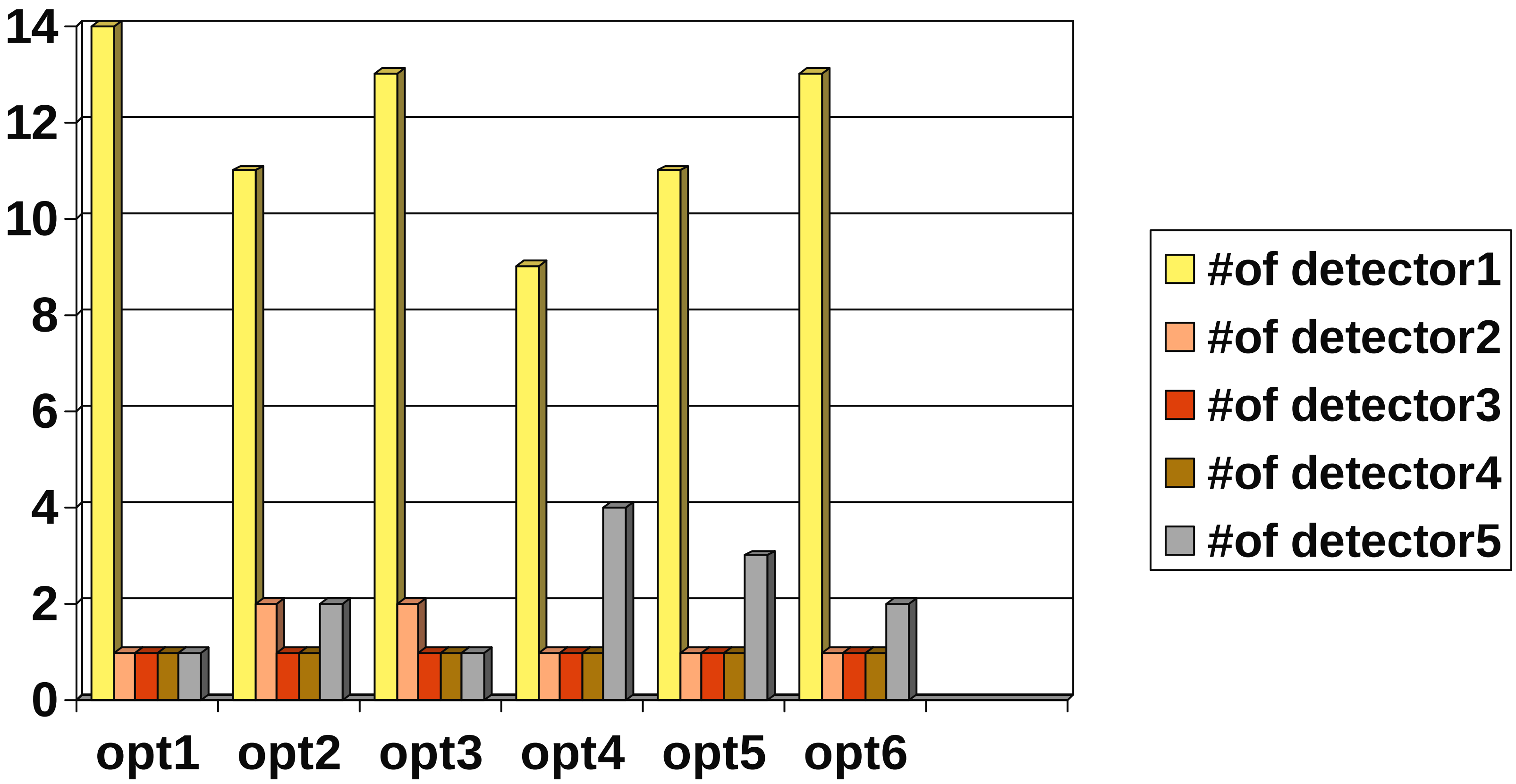
Optimization

10 options of $(\Delta\theta_1,\ldots,\Delta\theta_5)$ with their corresponding amount of money.

$(\Delta\theta_1,\ldots,\Delta\theta_5)=(14,1,1,1,1)$, with $M=97$;
$(\Delta\theta_1,\ldots,\Delta\theta_5)=(11,2,1,1,2)$, with $M=99$;
$(\Delta\theta_1,\ldots,\Delta\theta_5)=(13,2,1,1,1)$, with $M=99$;
$(\Delta\theta_1,\ldots,\Delta\theta_5)=(9,1,1,1,4)$, with $M=100$;
$(\Delta\theta_1,\ldots,\Delta\theta_5)=(11,1,1,1,3)$, with $M=100$;
$(\Delta\theta_1,\ldots,\Delta\theta_5)=(13,1,1,1,2)$, with $M=100$;
$(\Delta\theta_1,\ldots,\Delta\theta_5)=(15,1,1,1,1)$, with $M=100$;
$(\Delta\theta_1,\ldots,\Delta\theta_5)=(10,3,1,1,2)$, with $M=101$;
$(\Delta\theta_1,\ldots,\Delta\theta_5)=(12,3,1,1,1)$, with $M=101$;
$(\Delta\theta_1,\ldots,\Delta\theta_5)=(6,2,1,1,5)$, with $M=102$;

Optimization

Histogram for the options



Optimization

2. Optimization of vector-valued "utility function" using decision-makers' preferences.

To optimize $\varphi(X)=(c_1(X),\ldots,c_m(X))^T$ where $X=(x_1,\ldots,x_k)$, we can use the common method of weighted linear combination of the components c_j (X), i.e., optimize

$$\sum_{j=1}^{m} w_j c_j(x)$$

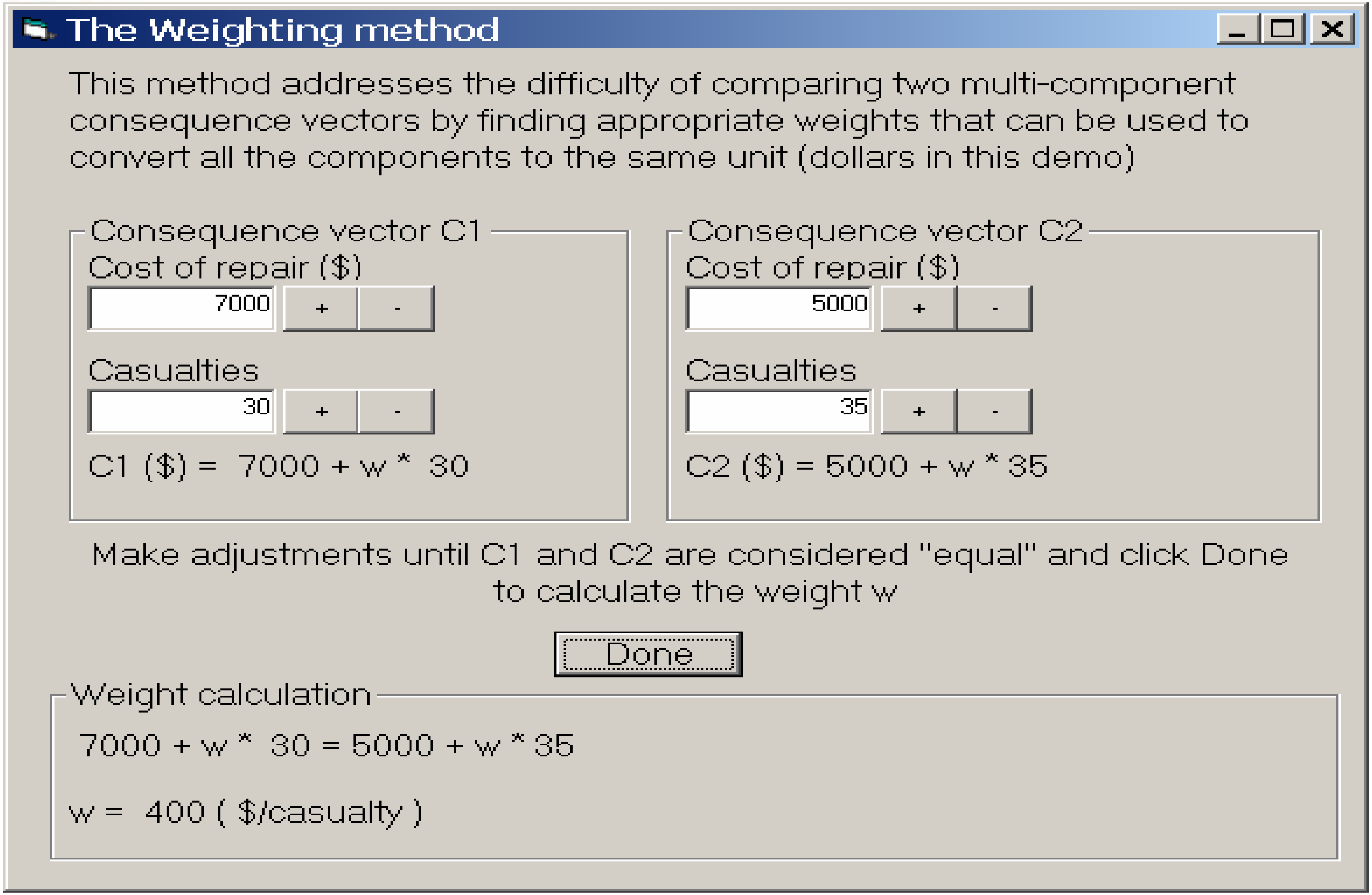
where w_j is the scaling weight for c_j.

Optimization

How to obtain the w_j's?

Example: Let $c_1(X)$=repair cost ($), $c_2(X)$=human casualties. The overall utility function is expressed in $. So $w_1=1$. Decision makers will be asked to express their preferences among consequences leading to the identification of w_2 (Keeney and Raiffa, 1993).

The weighting method



Optimization

3. Some optimization methods

a) Genetic algorithms

This "evolutionary" type of optimization method is appropriate for non-smooth objective functions. The method is inspired from the reproduction process in biology. This method is designed to optimize an objective function f for which we do not know its analytic expression but, given input $\theta = (\theta_1, \theta_2, \ldots, \theta_k)$, the value $f(\theta)$ can be found.

Optimization

b). Stochastic approximation (Robbins and Monro, 1951)

This method is designed to optimize an unknown function f(θ) when , for specified θ, the value f(θ) can be provided. This can be done by asking experts from MIIS.

Problem: Find a minimum point, $\theta^* \in R^p$, of a real-valued function f(θ), called the "loss function," that is observed in the presence of noise.

Optimization

(1) Finite Difference: The iterative procedure is

$$\hat{\theta}_{k+1} = \hat{\theta}_k - a_k \hat{g}_k(\hat{\theta}_k)$$

$$\hat{g}_{ki}(\hat{\theta}_k) = \frac{y(\hat{\theta}_k + c_k e_i) - y(\hat{\theta}_k - c_k e_i)}{2c_k}$$

a_k: goes to 0 at a rate neither too fast nor too slow,
$y(\theta)$: the observation of $f(\theta)$,
e_i: a vector with a 1 in the ith place, and 0 elsewhere,
c_k: goes to 0 at a rate neither too fast nor too slow.
Initialize $\hat{\theta}_1$, calculate $\hat{g}_1(\hat{\theta}_1)$ and $\hat{\theta}_2$, …, continue this process till $\hat{\theta}_k$ converges to $\hat{\theta}^*$, which is our optimization solution.

Optimization

Example: Let $X = \begin{bmatrix} 7 & 1 & 5 & 4 & 7 & 6 \\ 0 & 6 & 3 & 5 & 6 & 7 \\ 1 & 3 & 7 & 7 & 3 & 7 \\ 2 & 6 & 0 & 1 & 1 & 1 \end{bmatrix}$ $C = \begin{bmatrix} 22 \\ 36 \\ 2 \\ 30 \end{bmatrix}$ $\theta = \begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \\ \theta_6 \end{bmatrix}$

and $\varepsilon \sim N(0,1)$

Optimize $f(\theta)=(X\theta-C)'(X\theta-C)+\varepsilon$ with Finite Difference procedure,we get the result as follows:

$$\hat{\theta} = [1.1823\ 4.1721\ -2.5319\ -1.0656\ 3.3252\ 0.5283]'$$

It is close to the result of the case where the observations are not influenced by noise:

$$[1.1667\ \ 4.1257\ -2.6528\ \ -1.0799\ 3.3395\ \ 0.6524]'$$

Optimization

(2) Simultaneous Perturbation Stochastic Approximation (SPSA) with Injected Noise (Maryak and Chin, 2001):to obtain global minimum.

$$\hat{\theta}_{k+1} = \hat{\theta}_k - a_k \hat{g}_k(\hat{\theta}_k) + q_k \varpi_k$$

$$\hat{g}_k(\theta) = (2c_k\Delta_k)^{-1}[y(\theta + c_k\Delta_k) - y(\theta - c_k\Delta_k)]$$

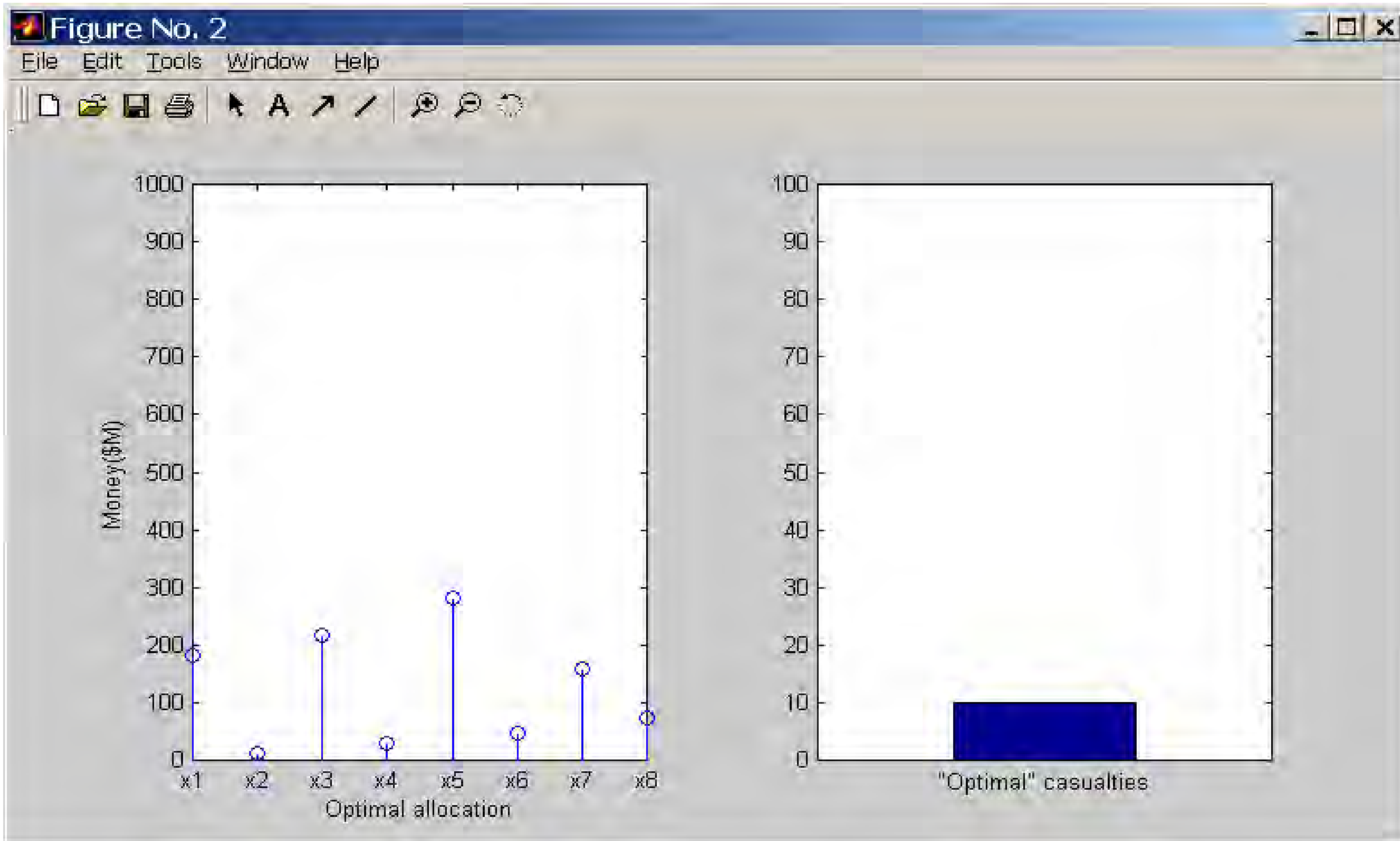
a_k, c_k, q_k:goes to 0 at a rate neither too fast nor too slow;

y(.): the observation of f(.);

Δ_k: distributed as Bernoulli (±1);

w_k: i.i.d. in N_k (0,1).

Optimization of mockup math model using simulated annealing



Ranking

- Rank solutions $X = (X_1, X_2\ldots X_k)$ obtained via optimization to find the most "efficient" one (Multi-criteria decision making, with the mitigating variables $\theta_1,\theta_2\ldots\theta_k$ as criteria).
- Goal: define a total order between alternatives, i.e. define a map $\varphi:\Re^k \rightarrow \Re$, so that alternative X is preferred to alternative Y if $\varphi(Y) \leq \varphi(X)$.
- The total order should reflect the degrees of importance of each criterion θ_i in its contribution to the "total score" $\varphi(X)$.

Ranking

- In our ranking problem, the criteria are interactive, e.g. mitigating variables can contribute to damage reduction in combinations.
- Non-linear aggregation operators are proved more efficient in such situation than linear ones but may be computationally prohibitive.
- Approximation can be done with a linear aggregation operator based on simple analysis of interaction between criteria.

Ranking

1. Ranking with AHP

- Linear aggregation operator based on simple analysis of interaction between criteria, namely, pair-wise comparisons.
- Uses fuzzy logic to extract degrees of importance between pairs of criteria, and conducts a synthesis of priorities leading to a weighted average operator.
- Can handle linguistic (qualitative) values of allocations.

Ranking

2. Ranking with Choquet Integral

- Non-linear aggregation operator (more general and axiomatically justified).

Description of Discrete Choquet Integral:

Denote $T = (c_1, c_2, \cdots, c_k)$ to be the set of k criteria,

$x = (x_1, x_2, \cdots, x_k)$ to be the evaluations on the subject x.

A fuzzy measure on power set 2^T satisfies

a. $\mu(0) = 0, \mu(T) = 1$ and,

b. $A \subseteq B$ implies $\mu(A) \leq \mu(B)$ for $A, B \subseteq T$.

Discrete Choquet integral with respect to the fuzzy measure is given by

$$C_\mu(x) = \sum_{i=1}^{k} (x_{(i)} - x_{(i-1)}) \mu(A_{(i)})$$

with $x_{(0)} = 0$, and $A_{(i)} = \{c_{(i)}, \cdots, c_{(k)}\}$, where $(x_{(1)}, \cdots, x_{(k)})$ is ranked $(x_1, \cdots, x_k)$ in increasing order, $\{c_{(i)}, \cdots, c_{(k)}\}$ is the subset of criteria corresponding to $\{x_{(i)}, \cdots, x_{(k)}\}$

Ranking

Example: *Rank ten 5-component consequence vectors, with the fuzzy measure μ=[0.07 0.07 0.07 0.27 0.27 0.35 0.37 0.37 0.37 0.37 0.47 0.47 0.55 0.47 0.59 0.27 0.27 0.27 0.29 0.29 0.39 0.39 0.39 0.57 0.57 0.63 0.63 0.65 0.75 0.75]:*

Consequence vectors	Choquet integrals	Rank	Consequence vectors	Choquet integrals	Rank
(14,1,1,1,1)	6.33	2	(13,1,1,1,2)	6.29	3
(11,2,1,1,2)	5.59	7	(15,1,1,1,1)	6.74	1
(13,2,1,1,1)	6.14	4	(10,3,1,1,2)	5.40	8
(9,1,1,1,4)	5.39	9	(12,3,1,1,1)	5.95	5
(11,1,1,1,3)	5.84	6	(6,2,1,1,5)	4.64	10

Ranking

3. Identification of fuzzy measures

Fuzzy measures have to satisfy the monotone constraints.

Two methods to identify fuzzy measures μ:

i) *Supervised learning*

a) Quadratic programming

b) Neural network

ii) *Unsupervised learning (Method of Entropy)*

Viewing criteria as a random vector, and allocations as random sample. Estimating all joint partial density functions. Using entropies of subsets of criteria as fuzzy measure value.

Ranking

a. Identification of fuzzy measures with quadratic programming

For the following data

x_1 =(1 1 .9 .7 .5) x_2 =(.3 .1 1 .9 .6) x_3 =(.5 .7 .3 .5 .9)

x_4 =(1 .5 .4 .1 .5) x_5 =(.8 .6 .8 .8 .7) x_6 =(.4 .0 .2 .7 .9)

x_7 =(.9 .8 .9 1 .3) x_8 =(.5 1 1 .5 .1) x_9 =(.7 .9 .8 .2 .7)

$Y = (y_1, y_2,\ldots,y_9)$ =(.7 .6 .5 .3 .8 .5 .7 .5 .4).

By our algorithm, we get

μ = [0.0700 0.0700 0.0700 0.2700 0.2700

0.3500 0.3700 0.3700 0.3700 0.3700

0.4700 0.4700 0.5500 0.4700 0.5900

0.2700 0.2700 0.2700 0.2900 0.2900

0.3900 0.3900 0.3900 0.5700 0.5700

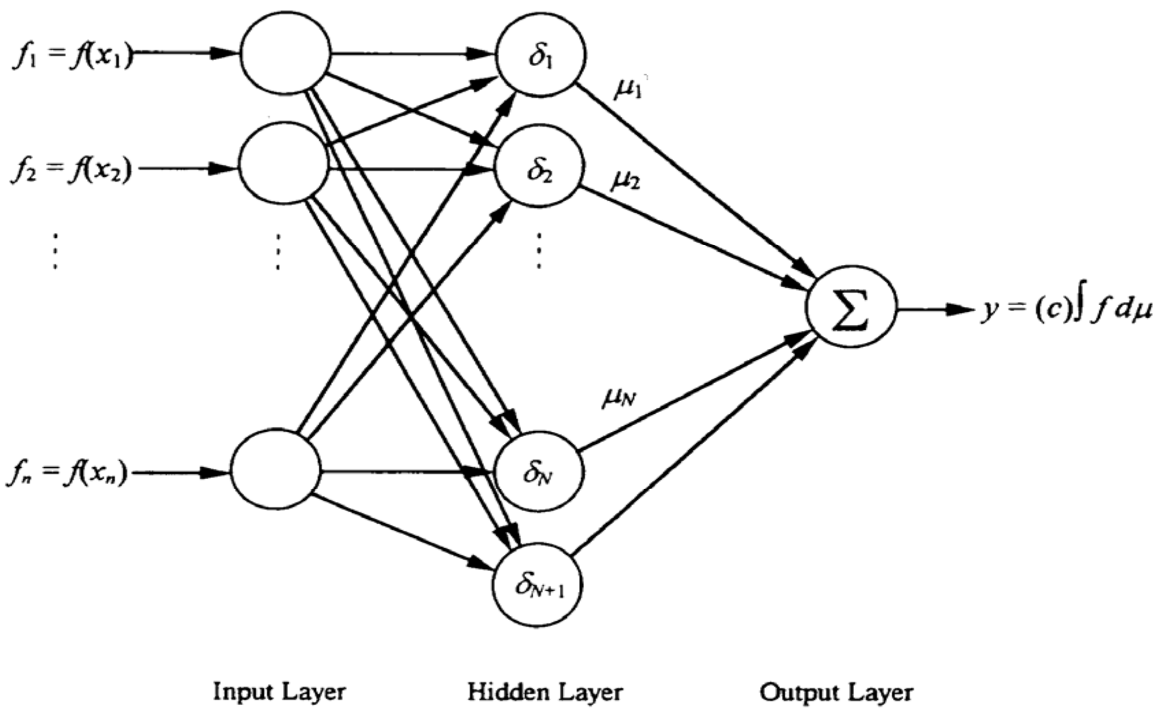
0.6300 0.6300 0.6500 0.7500 0.7500]

The corresponding quadratic error is 0.0084.

Ranking

b. Identification of fuzzy measures with neural networks

Fuzzy measures are set up as weights of a feed forward neural network, which are found by training the network with back-propagation algorithm. (Wang and Wang, 1997).



Ranking

Example: identification of fuzzy measures with neural networks

Sample	Feature 1	Feature 2	Feature 3	Evaluation
1	0.56	0.78	0.92	0.742984
2	0.05	0.36	0.18	0.143036
3	0.97	0.95	0.84	0.881246
4	0.00	0.62	0.06	0.090632
5	0.22	0.15	0.00	0.064790
6	1.00	0.75	0.33	0.522212
7	0.49	0.55	0.76	0.608632
8	0.89	0.37	0.97	0.794288
9	0.64	0.59	1.00	0.771720
10	0.11	0.00	0.03	0.038632

Our network produces the following fuzzy measure: $\mu\{\}= 0$, $\mu\{1\}= 0.2$, $\mu\{2\}= 0.1$, $\mu\{1,2\}=0.3386$, $\mu\{3\}= 0.399$, $\mu\{1,3\}= 0.7544$, $\mu\{2,3\}= 0.5772$ $\mu\{1,2,3\}=1$, which satisfies the monotone constraints.

Conclusions and Future Work

- Data structure
- Experts and decision-makers’ assistance
- Optimization methods
- Ranking procedures
- Some other issues

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Virtual Prototyping Feasibility/Benefit and CB Common Knowledge Base BA05MSB061

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Virtual Prototyping Feasibility/Benefit and CB Common Knowledge Base,

SCOPE

First, analysis and experimentation to determine the feasibility of virtual prototyping in support of CBRN developmental programs and quantify the benefit of virtual prototyping to these developmental programs. Second, develop an implementation plan for a Common Knowledge Base (CKB), which will become a community resource for the Chemical Biological Defense Program (CBDP).

- Work being performed by MSA Team, CBIAC, (and ITT as required)
- Synergy with ongoing PM CA efforts to develop component/system models

OUTCOME/STATUS

- Developed use case study plan. Metrics to quantify benefit of virtual prototyping still being evaluated.
- Needed JSLSCAD VP modifications coded
- Functional characteristics (black box) VP study nearly complete for JSLSCAD Field of Regard
- CBRN Data model training and review completed by the CBIAC team for version 1.2 of the CBRN Data Model
- Initial design and implementation plan for CB CKB ongoing

RELEVANCE

- The true benefit to a Program Manager (PM) in terms of cost, schedule or risk reduction, has not been demonstrated to an extent that the CBDP community will embrace the idea of virtual prototypes or prototyping.
- A body of agreed-upon data (threat agent date, environmental data, test data for past and current CBDP systems) that PMs and combat developers can access when doing analyses for various decisions is a long-standing need in the CBDP community.

ASSESSMENT

- VP is becoming a fact of life for at least the two CB PMs in this task
- Use cases straightforward—generalized quantification of VP benefits more difficult
- Expect transition in FY07 on completed CB CKB

Functional Performance VP Use Case

- PM addressing the issue of elevation angle extents for system field of regard
- Needed to consider impact of terrain, attack type, vehicle route, etc.
- Tradeoff between large FOR to avoid missing an attack and smaller FOR to increase probability of detecting attack given it is within the FOR
- Using a variant of CB Dial-A-Sensor™ (CB DAS) called CB Analyzer

Virtual Prototyping Use case for System Performance Requirements

CB Analyzer Adaptations

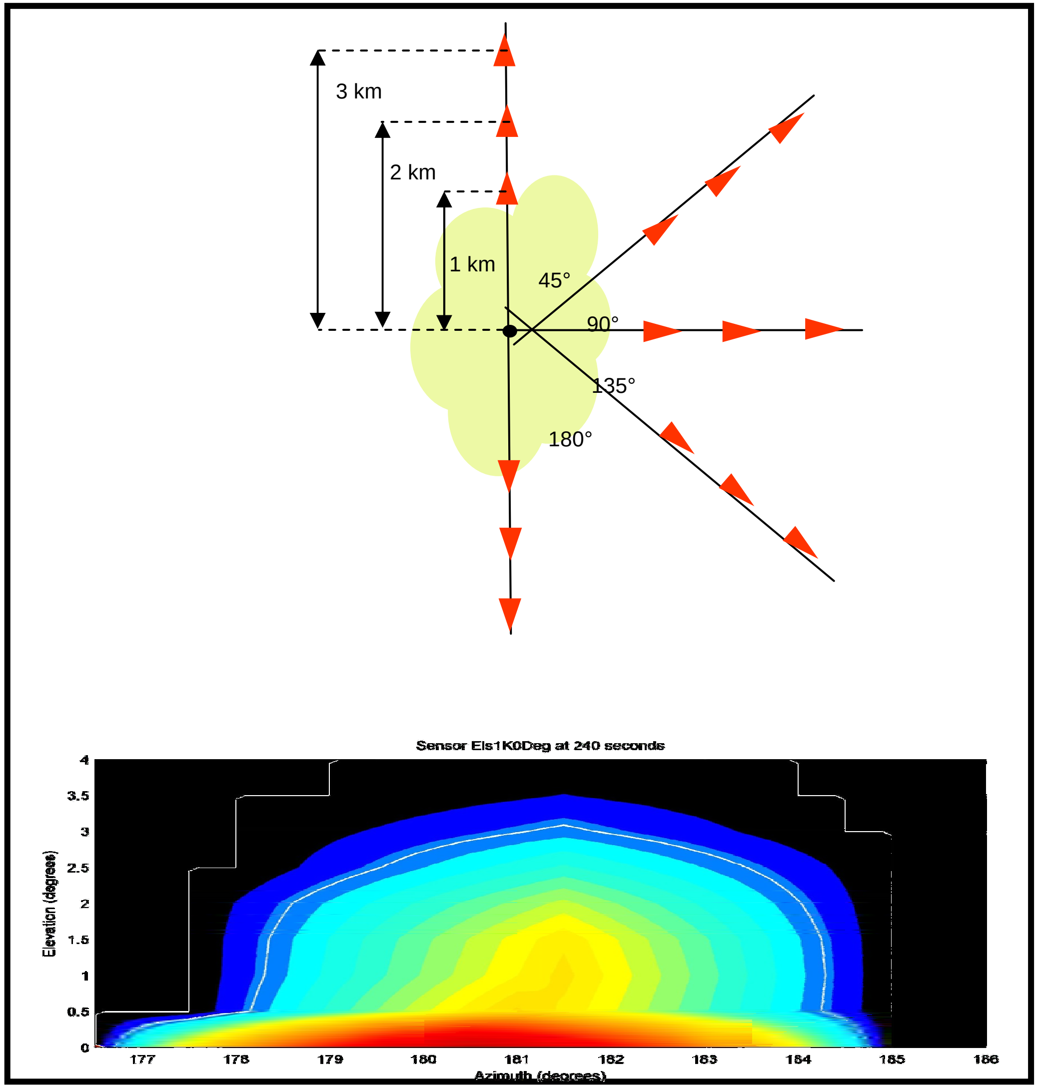
- Created capability to output the Minimum/Maximum detection Azimuths on cloud groups with air gaps between them. Analyzer originally assumed all clouds were in one large group.

- Created capability to output detailed and synopsis detection data to a text output file. This allowed easier ingestion for MathLab compared to the XML format.

- The Analyzer JSL Analysis Process (JSLAP) tool creates sensor positions around the cloud mass based off of distance and direction from the center of the cloud mass. The positions and distance to output were originally hard coded. JSLAP was modified to allow the user to select any distance and position to place a sensor.

Modifications funded by both PM and Tech Base collaboratively

JSLAP Tool



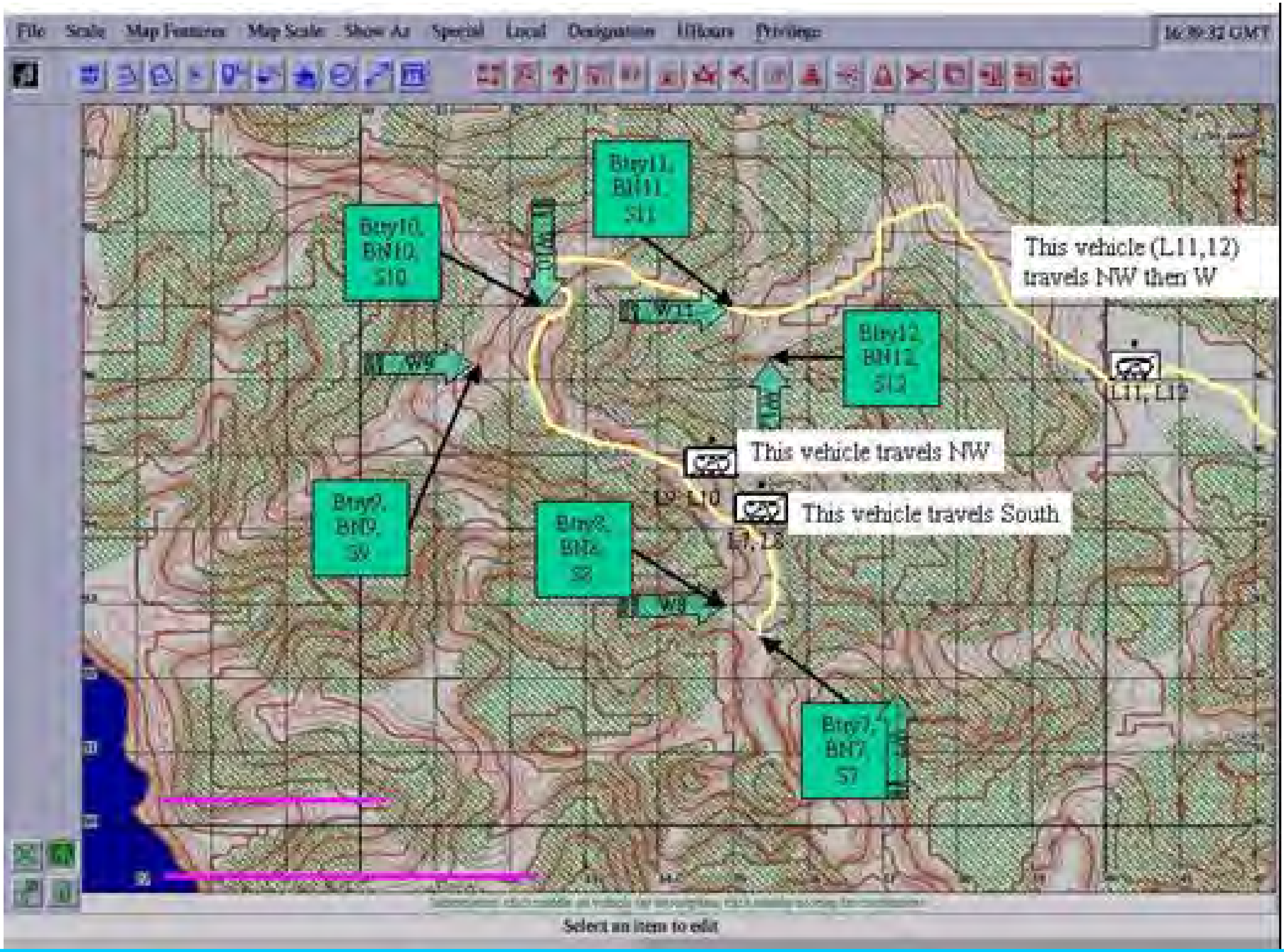
3 km
2 km
1 km
45°
90°
135°
180°
Sensor Els1K0Deg at 240 seconds
Elevation (degrees)
Azimuth (degrees)

Operational Vignette
Moderate Elevation Terrain

All vehicles travel from SE to NW along recon route

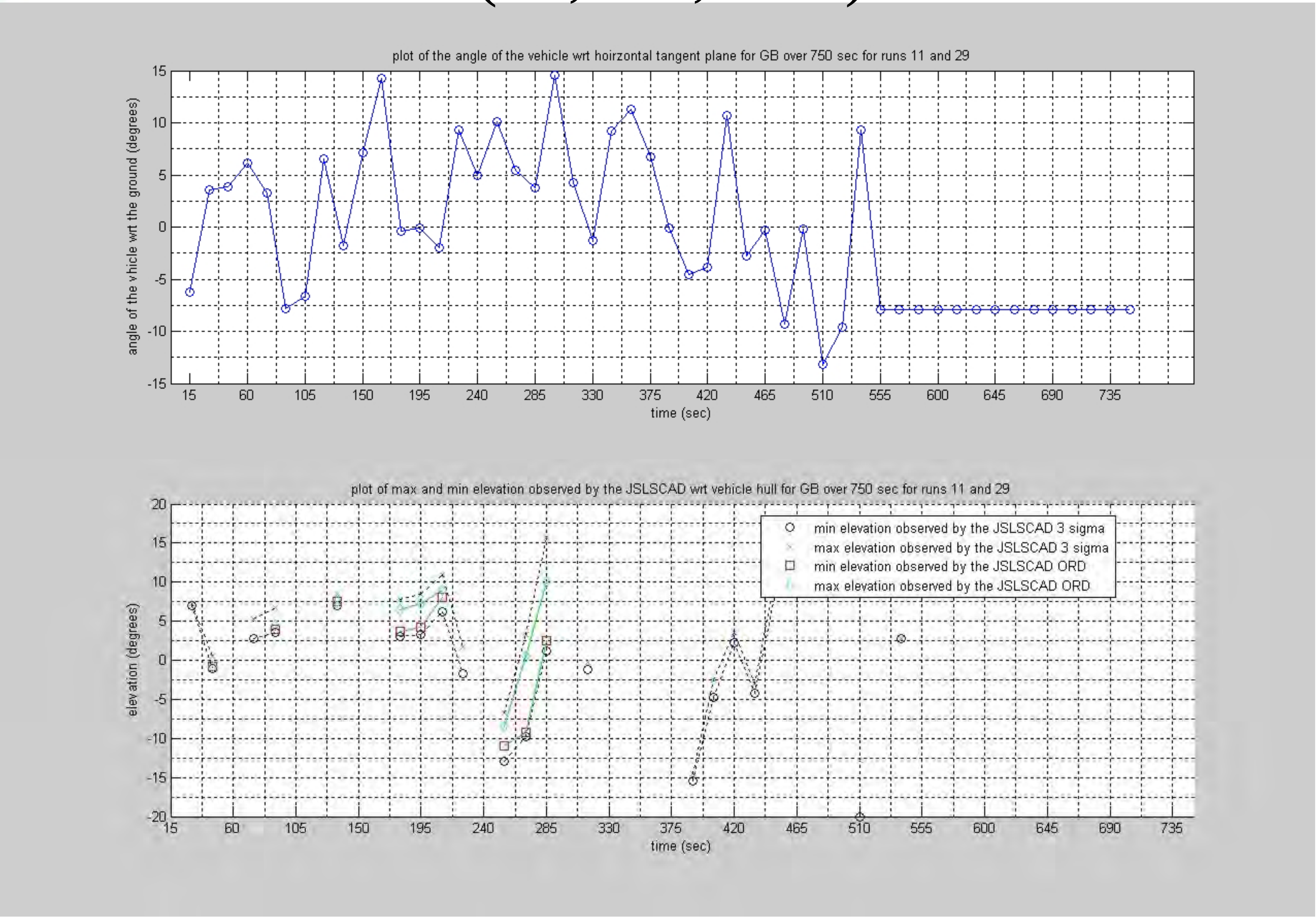
Extend system evaluation to conditions not currently tested

Operational Vignette
Mountainous Elevation Terrain



Extend system evaluation to conditions not currently tested

Use Case Example Results
(L5, W5, BN5)



M&S Captures the Decidedly Dynamic Situation

PM Perceptions

- Using VP to clarify/refine performance requirements translates to cost savings due to avoiding redesign
- PMs see need as they are funding on their own; however…
- A common VPS or suite would lead to better reuse of code
- Final quantification of benefit depends on:
  – Acceptance by T&E community
  – Ability to perform and document VV&A
  – Success or failure of PM to get performance requirements modified based on M&S results

Benefit Quantification Ongoing

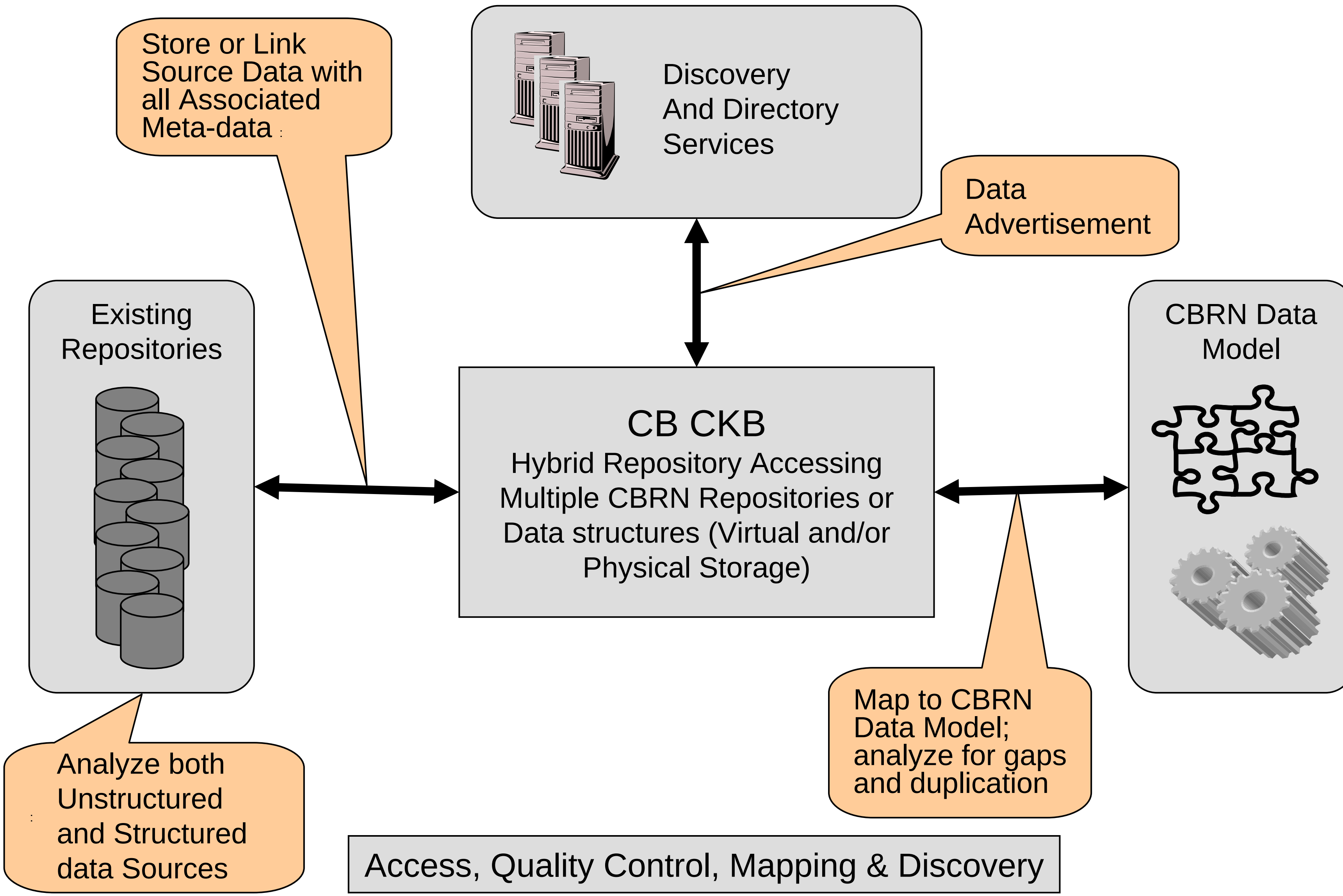
CB Common Knowledge Base (CB CKB)

- **TASK:** Develop a coordinated CB CKB which will become a community resource for the Chemical Biological Defense Program (CBDP)

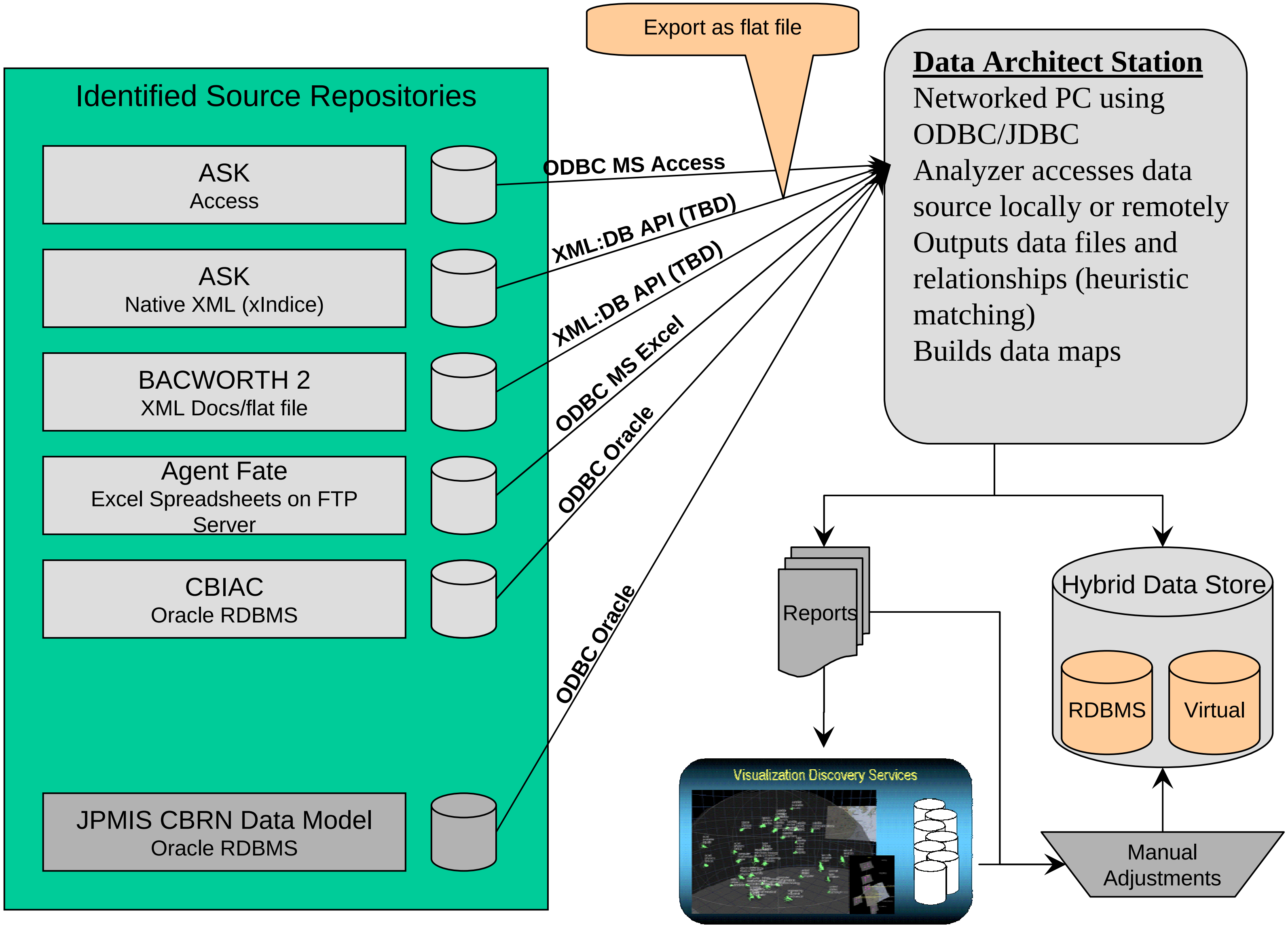
- **Overall Program Goals:**
  - Conduct data level technical analysis of existing CB repositories
  - Compare to the CBRN data model produced by JPM IS
  - Produce implementation plan to establish, validate and provide data set product standards and performance metrics for those sources that will become a community-accessible resource ('05)
  - Implement a Pilot CKB supporting Detection VP ('06)
  - Establish a Secure On-Line CB CKB System for CB Community (expanded domains) ('07)

Community Resource for the Chemical Biological Defense Program

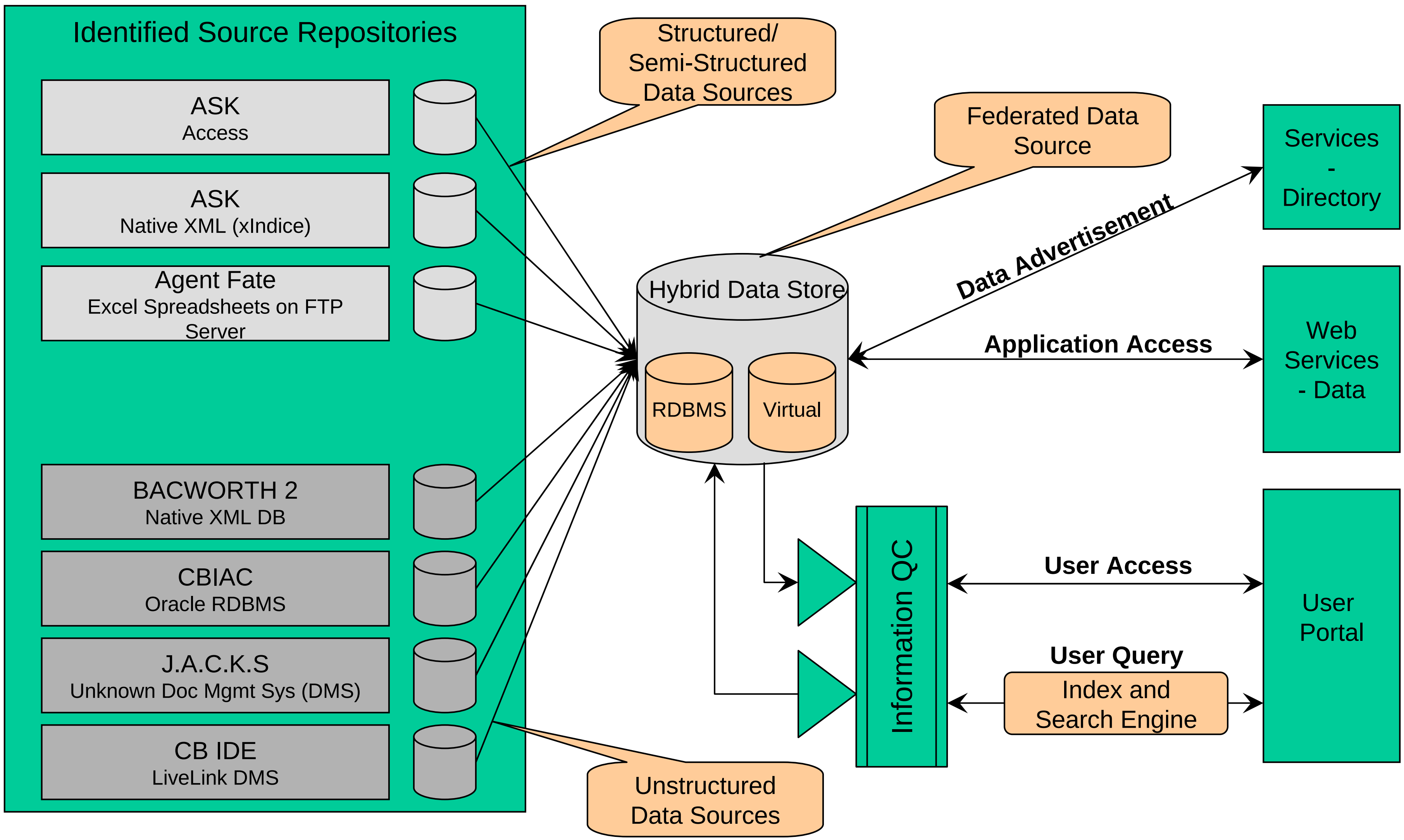
CB CKB Architecture



Information Fusion Build Process



Information QC and Access



CB CKB Milestones

- Phase 1 Milestones (June – Nov ‘05)
  - Define Data Requirements
  - Recommend Data-Centric Processes
  - Define CB CKB System
- Phase 2 Milestones (FY06)
  - Data Domain Analysis and Integration
  - Data Model Development
  - Engineering Design and Pilot System Development
- Phase 3 Milestones (FY07)
  - Establish Secure on-line CB CKB
  - Implement Process to Manage Data on CB CKB

Process and Methods to ensure future CB data is available and valid

Virtual Prototyping Feasibility/Benefit and CB Common Knowledge Base BA05MSB061

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Virtual Prototyping Feasibility/Benefit and CB Common Knowledge Base,

SCOPE

First, analysis and experimentation to determine the feasibility of virtual prototyping in support of CBRN developmental programs and quantify the benefit of virtual prototyping to these developmental programs. Second, develop an implementation plan for a Common Knowledge Base (CKB), which will become a community resource for the Chemical Biological Defense Program (CBDP).

- Work being performed by MSA Team, CBIAC, (and ITT as required)
- Synergy with ongoing PM CA efforts to develop component/system models

OUTCOME/STATUS

- Developed use case study plan. Metrics to quantify benefit of virtual prototyping still being evaluated.
- Needed JSLSCAD VP modifications coded
- Functional characteristics (black box) VP study nearly complete for JSLSCAD Field of Regard
- CBRN Data model training and review completed by the CBIAC team for version 1.2 of the CBRN Data Model
- Initial design and implementation plan for CB CKB ongoing

RELEVANCE

- The true benefit to a Program Manager (PM) in terms of cost, schedule or risk reduction, has not been demonstrated to an extent that the CBDP community will embrace the idea of virtual prototypes or prototyping.
- A body of agreed-upon data (threat agent date, environmental data, test data for past and current CBDP systems) that PMs and combat developers can access when doing analyses for various decisions is a long-standing need in the CBDP community.

ASSESSMENT

- VP is becoming a fact of life for at least the two CB PMs in this task
- Use cases straightforward—generalized quantification of VP benefits more difficult
- Expect transition in FY07 on completed CB CKB

Functional Performance VP Use Case

- PM addressing the issue of elevation angle extents for system field of regard
- Needed to consider impact of terrain, attack type, vehicle route, etc.
- Tradeoff between large FOR to avoid missing an attack and smaller FOR to increase probability of detecting attack given it is within the FOR
- Using a variant of CB Dial-A-Sensor^{TM} (CB DAS) called CB Analyzer

Virtual Prototyping Use case for System Performance Requirements

CB Analyzer Adaptations

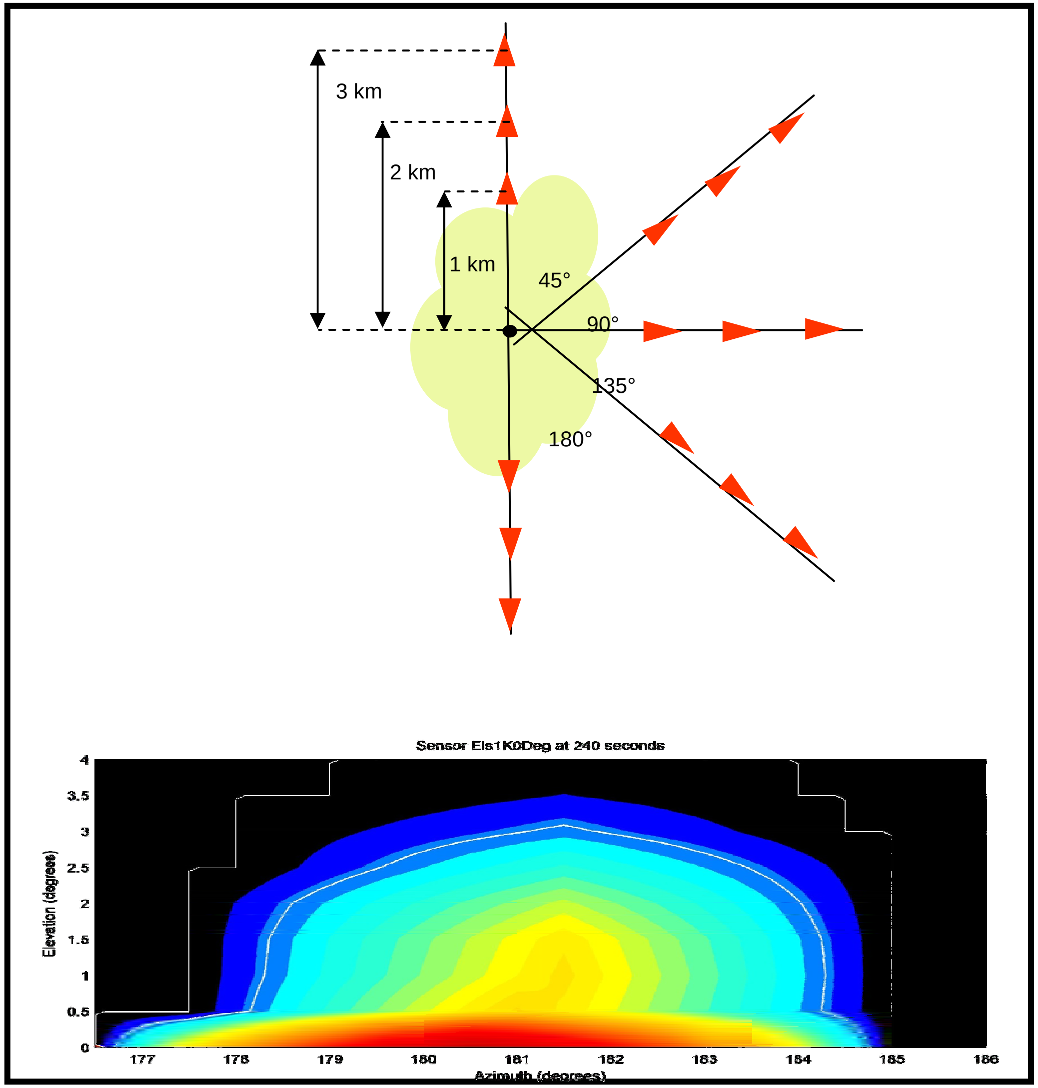
- Created capability to output the Minimum/Maximum detection Azimuths on cloud groups with air gaps between them. Analyzer originally assumed all clouds were in one large group.

- Created capability to output detailed and synopsis detection data to a text output file. This allowed easier ingestion for MathLab compared to the XML format.

- The Analyzer JSL Analysis Process (JSLAP) tool creates sensor positions around the cloud mass based off of distance and direction from the center of the cloud mass. The positions and distance to output were originally hard coded. JSLAP was modified to allow the user to select any distance and position to place a sensor.

Modifications funded by both PM and Tech Base collaboratively

JSLAP Tool



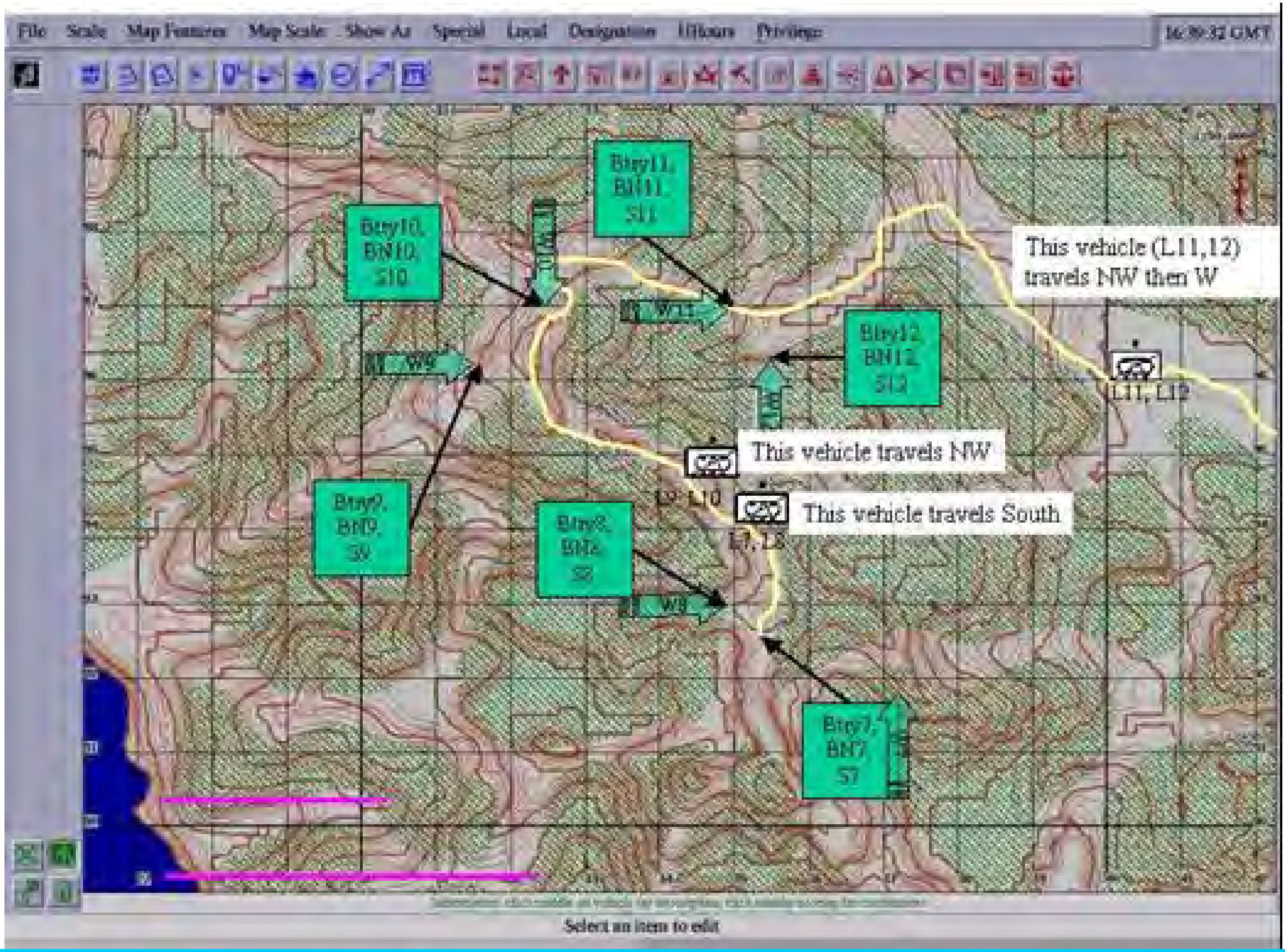
3 km
2 km
1 km
45°
90°
135°
180°
Sensor Els1K0Deg at 240 seconds
Elevation (degrees)
Azimuth (degrees)

Operational Vignette
Moderate Elevation Terrain

All vehicles travel from SE to NW along recon route

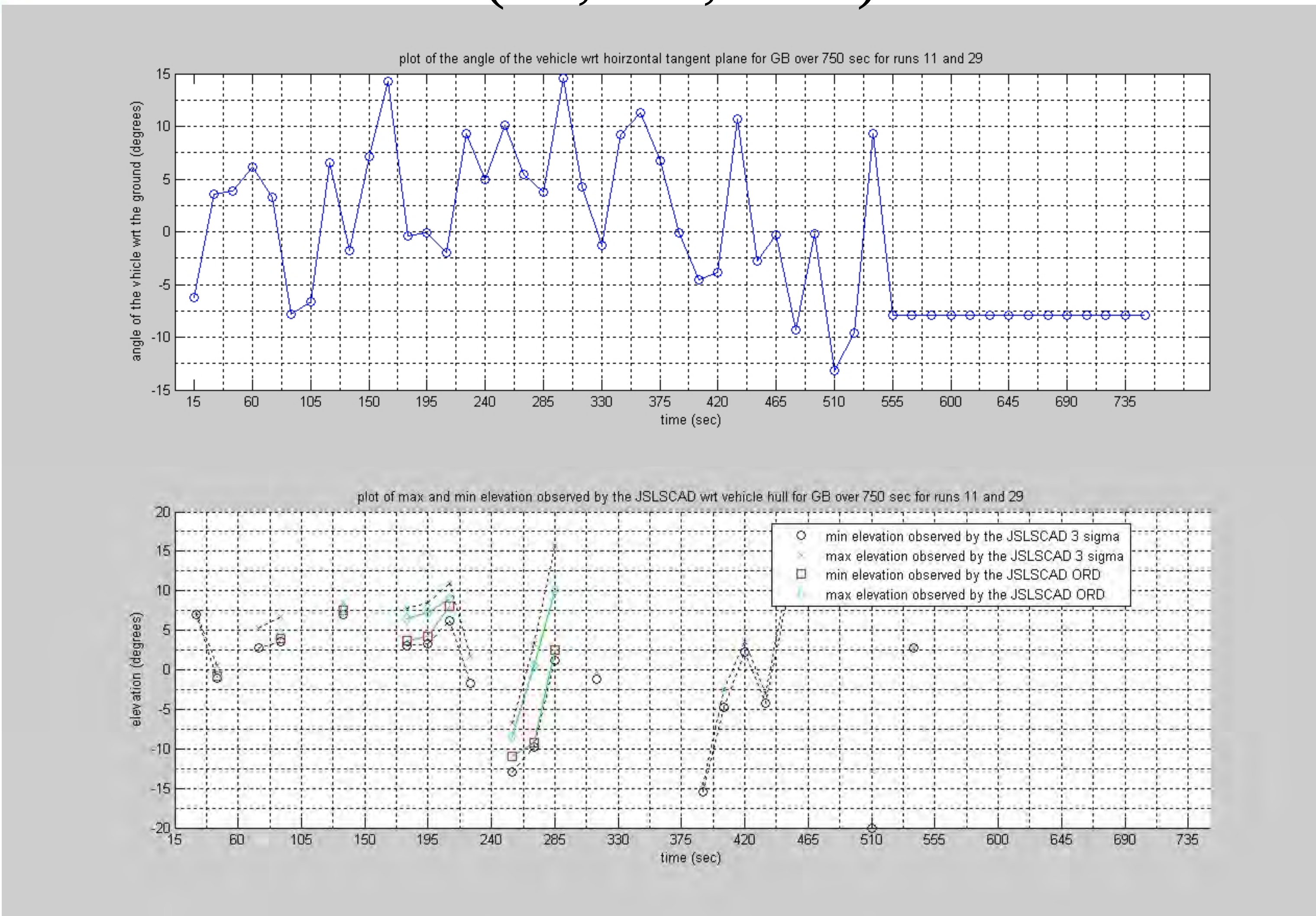
Extend system evaluation to conditions not currently tested

Operational Vignette
Mountainous Elevation Terrain



Extend system evaluation to conditions not currently tested

Use Case Example Results
(L5, W5, BN5)



M&S Captures the Decidedly Dynamic Situation

PM Perceptions

- Using VP to clarify/refine performance requirements translates to cost savings due to avoiding redesign
- PMs see need as they are funding on their own; however…
- A common VPS or suite would lead to better reuse of code
- Final quantification of benefit depends on:
  - Acceptance by T&E community
  - Ability to perform and document VV&A
  - Success or failure of PM to get performance requirements modified based on M&S results

Benefit Quantification Ongoing

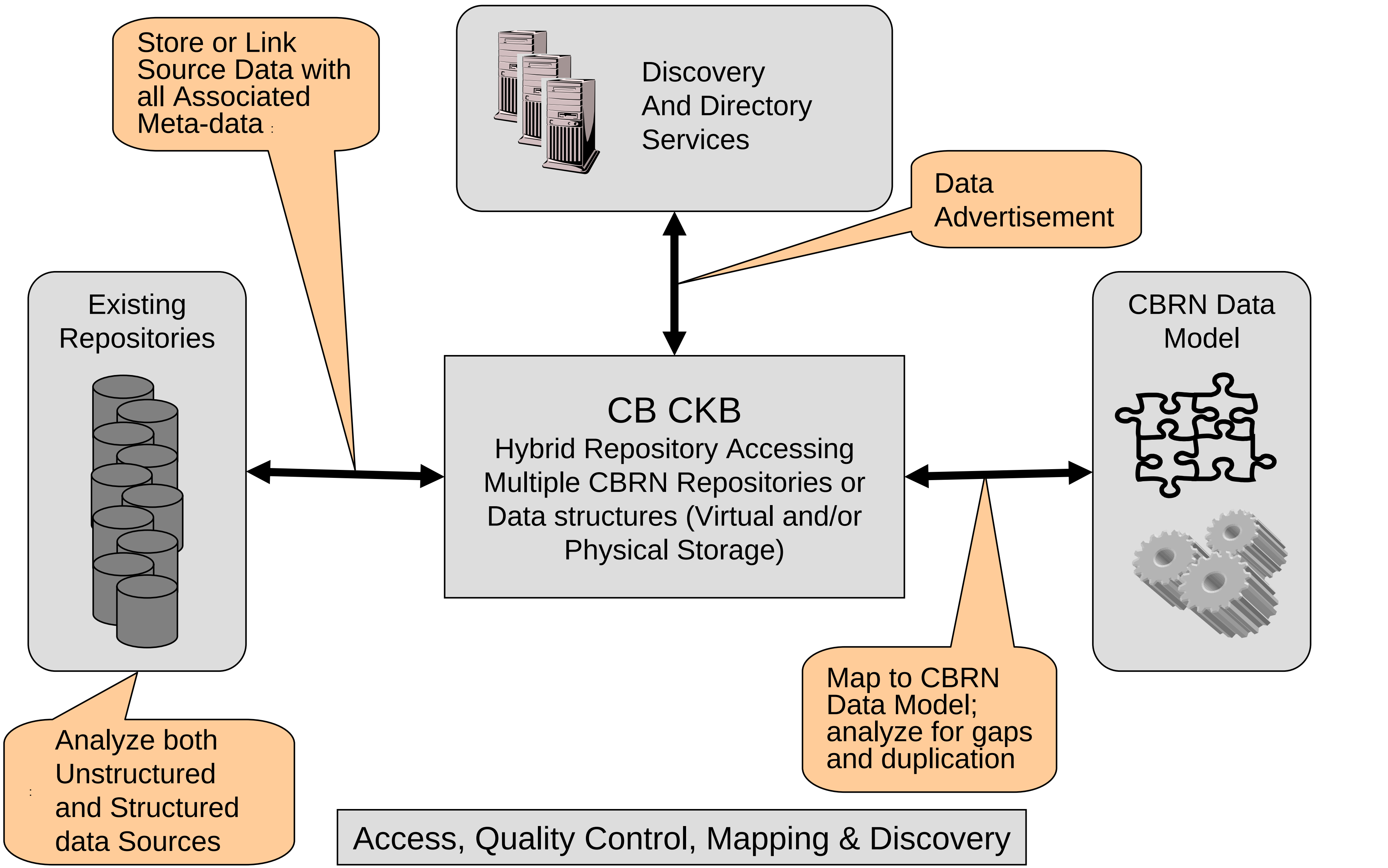
CB Common Knowledge Base (CB CKB)

- **TASK:** Develop a coordinated CB CKB which will become a community resource for the Chemical Biological Defense Program (CBDP)

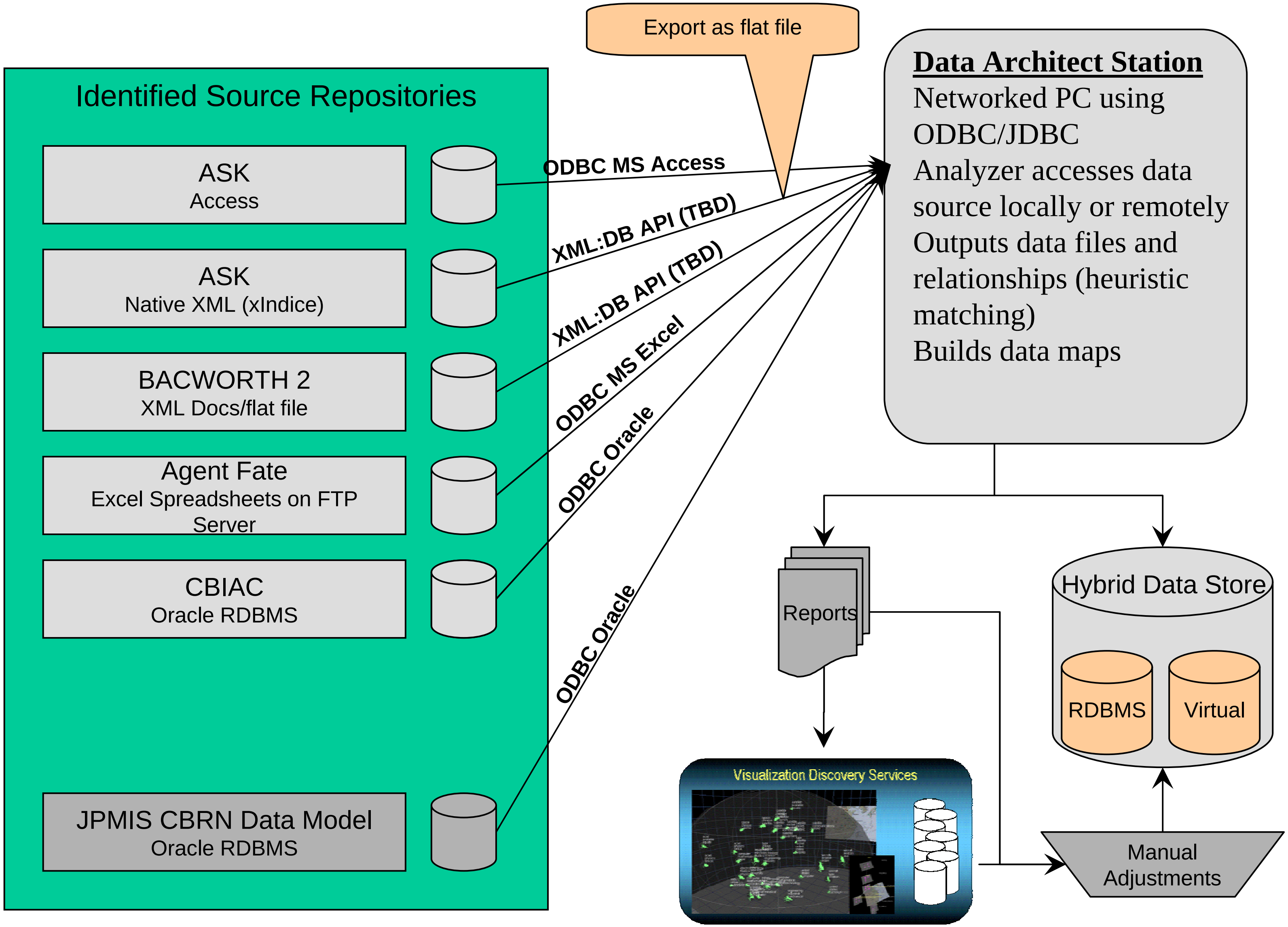
- **Overall Program Goals:**
  - Conduct data level technical analysis of existing CB repositories
  - Compare to the CBRN data model produced by JPM IS
  - Produce implementation plan to establish, validate and provide data set product standards and performance metrics for those sources that will become a community-accessible resource ('05)
  - Implement a Pilot CKB supporting Detection VP ('06)
  - Establish a Secure On-Line CB CKB System for CB Community (expanded domains) ('07)

Community Resource for the Chemical Biological Defense Program

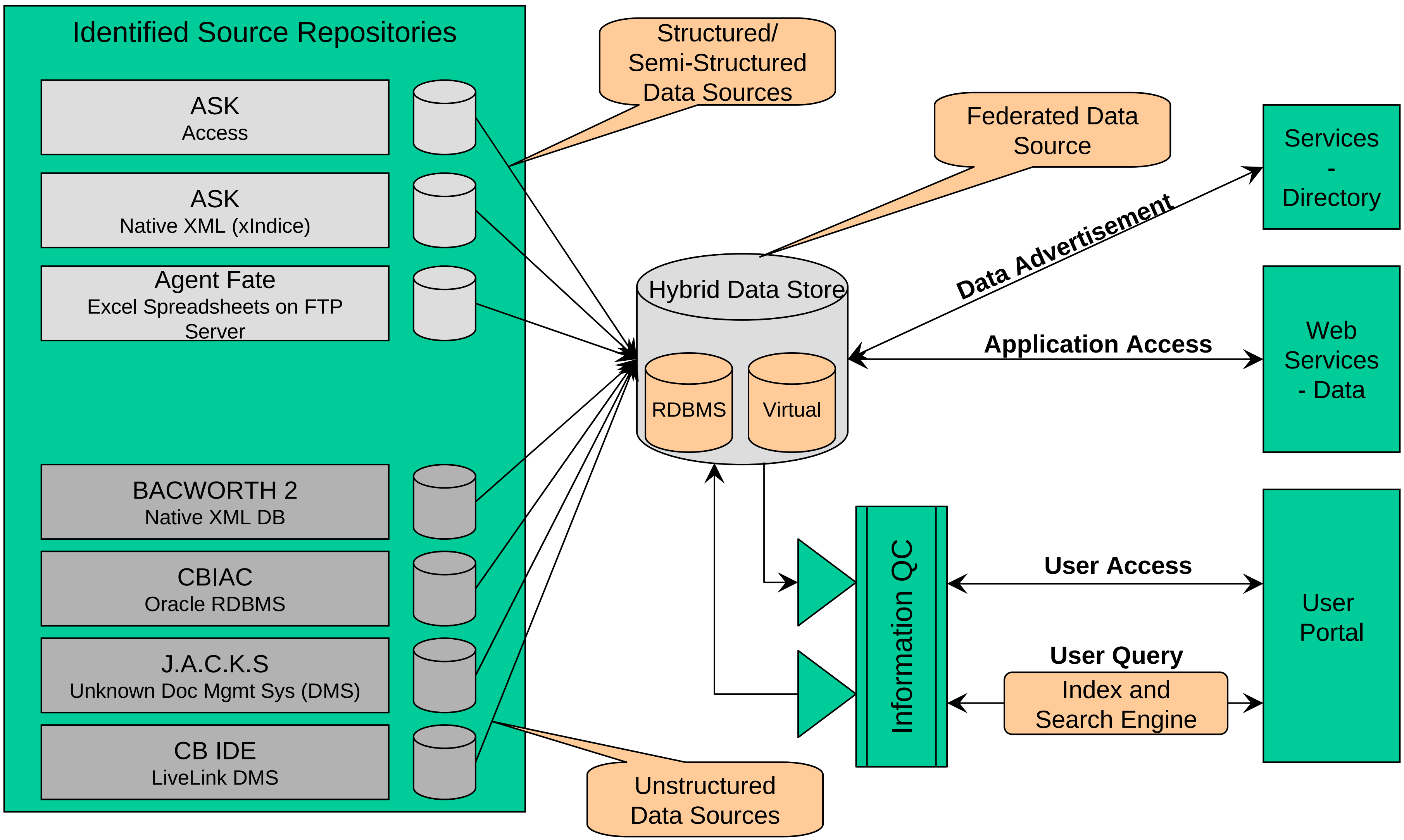
CB CKB Architecture



Information Fusion Build Process



Information QC and Access



CB CKB Milestones

- Phase 1 Milestones (June – Nov '05)
  - Define Data Requirements
  - Recommend Data-Centric Processes
  - Define CB CKB System
- Phase 2 Milestones (FY06)
  - Data Domain Analysis and Integration
  - Data Model Development
  - Engineering Design and Pilot System Development
- Phase 3 Milestones (FY07)
  - Establish Secure on-line CB CKB
  - Implement Process to Manage Data on CB CKB

Process and Methods to ensure future CB data is available and valid

A NEW BIO IMS FOR SIMULTANEOUS DETECTION OF CWAs AND BIOMATERIALS

by Dr. Jürgen Leonhardt

26 October 2005

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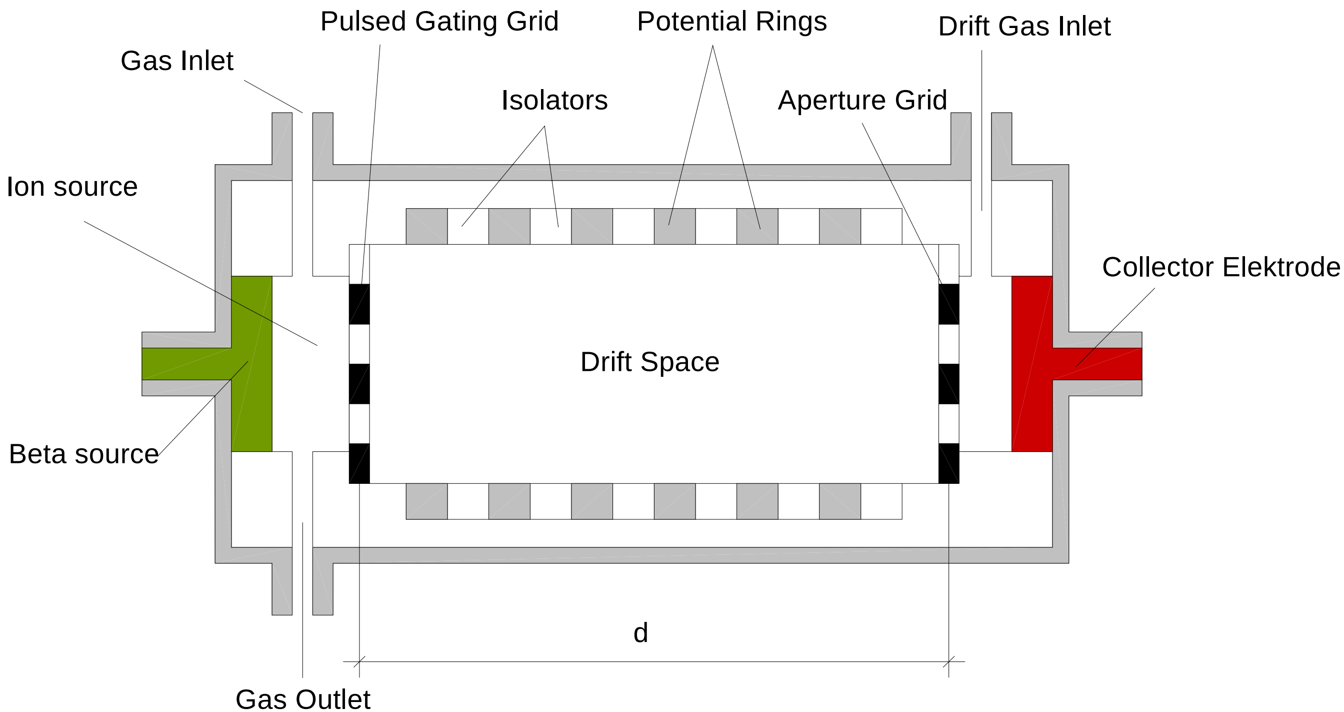
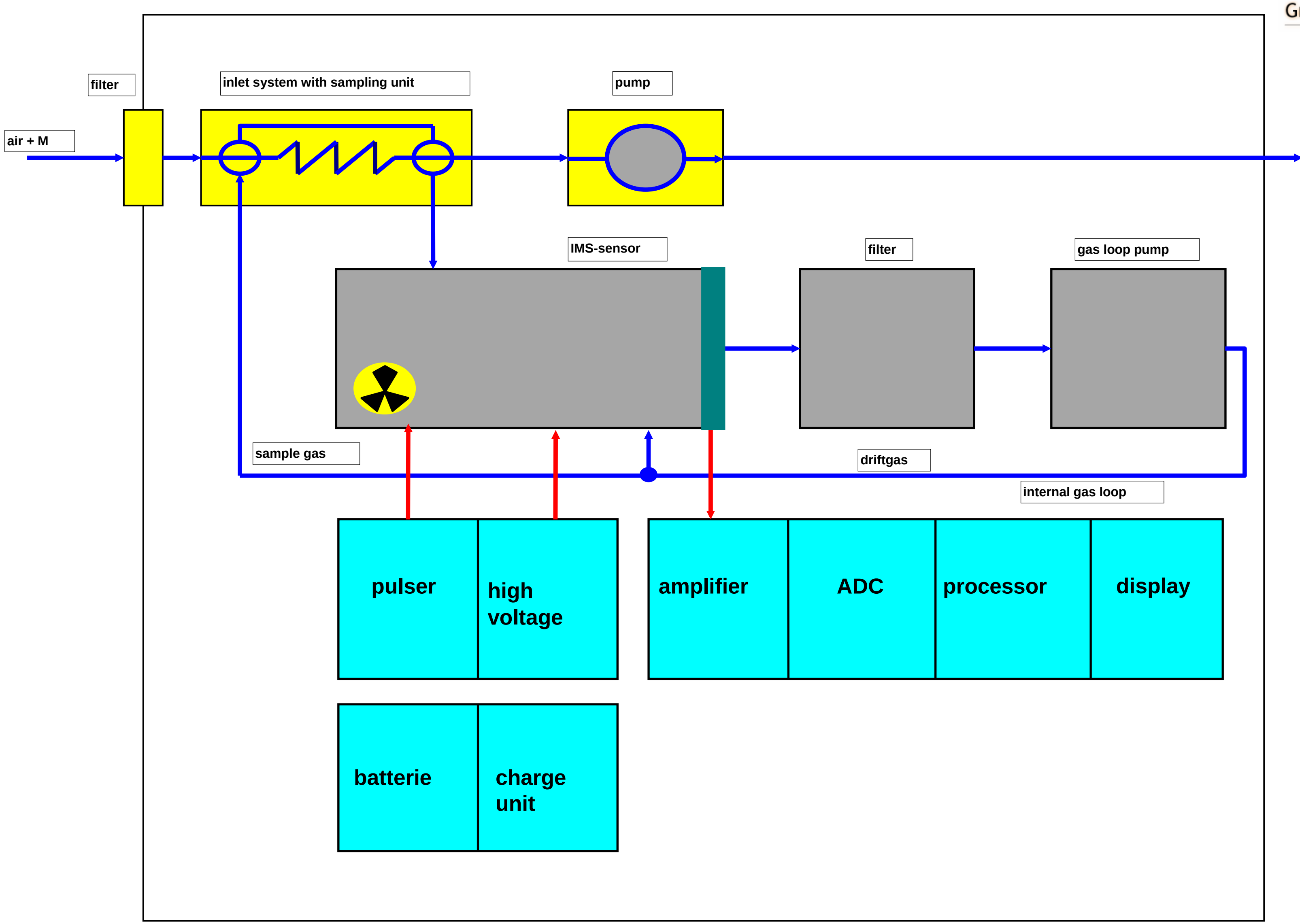
Isonics
corporation


Pulsed Gating Grid
Potential Rings
Drift Gas Inlet
Gas Inlet
Isolators
Aperture Grid
Ion source
Collector Elektrode
Drift Space
Beta source
d
Gas Outlet


filter
inlet system with sampling unit
pump
air + M
IMS-sensor
filter
gas loop pump
sample gas
driftgas
internal gas loop
pulser
high voltage
amplifier
ADC
processor
display
batterie
charge unit

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Chemical Warfare Agents	MDC (ppb)
Soman	1
Sarin	1
Tabun	1
S- Lost	10
N- Lost	10
Phosgene	3
HCN	15
Lewisit	5
VX	1

Toxic industrial compounds	MDC (ppb)
Acetone	1
Trichlorethylene	5
Cl2	10
Toluene	50
TDI	5
HF	5
HCl	5
Chlorcyan	5

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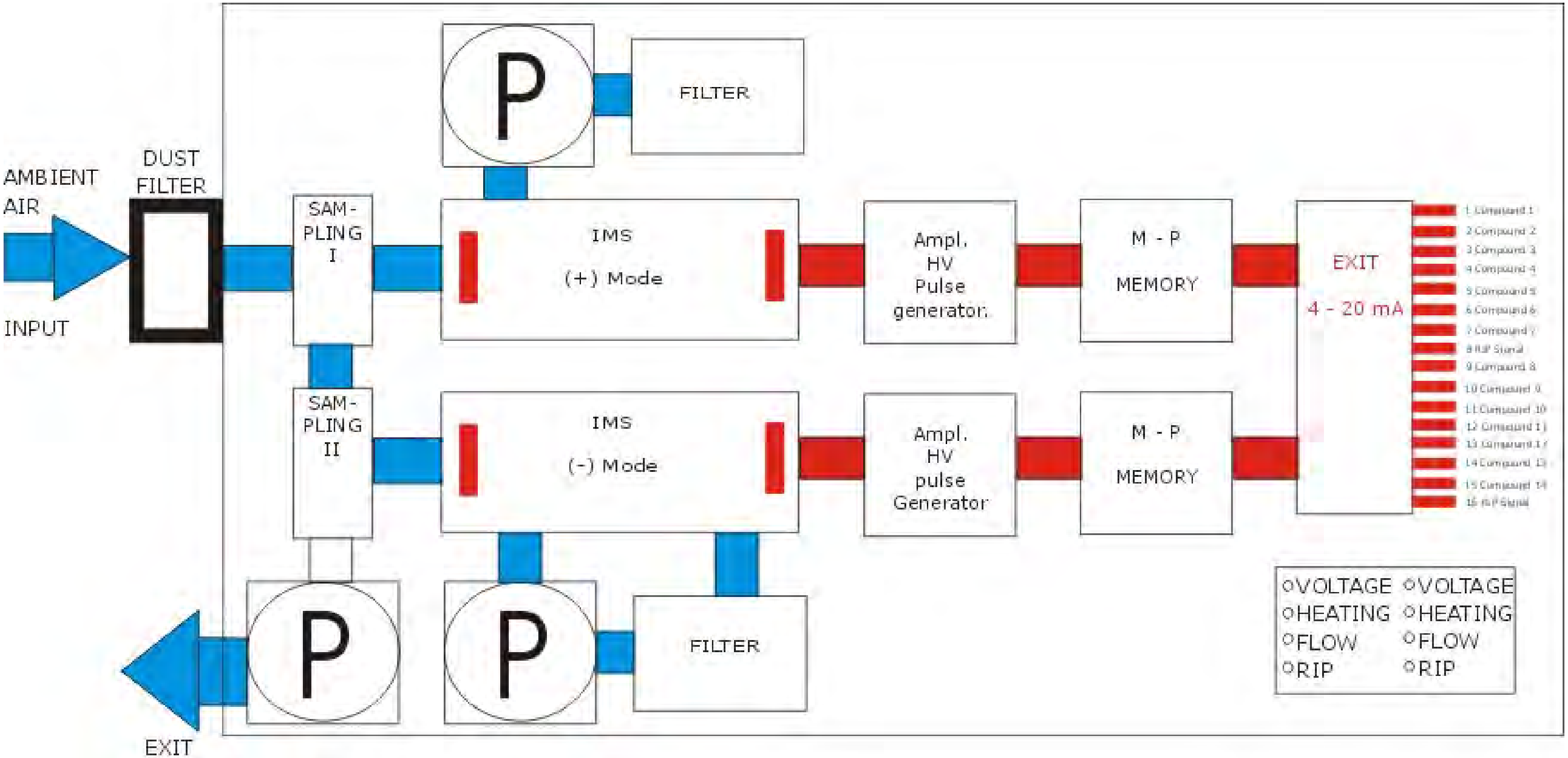
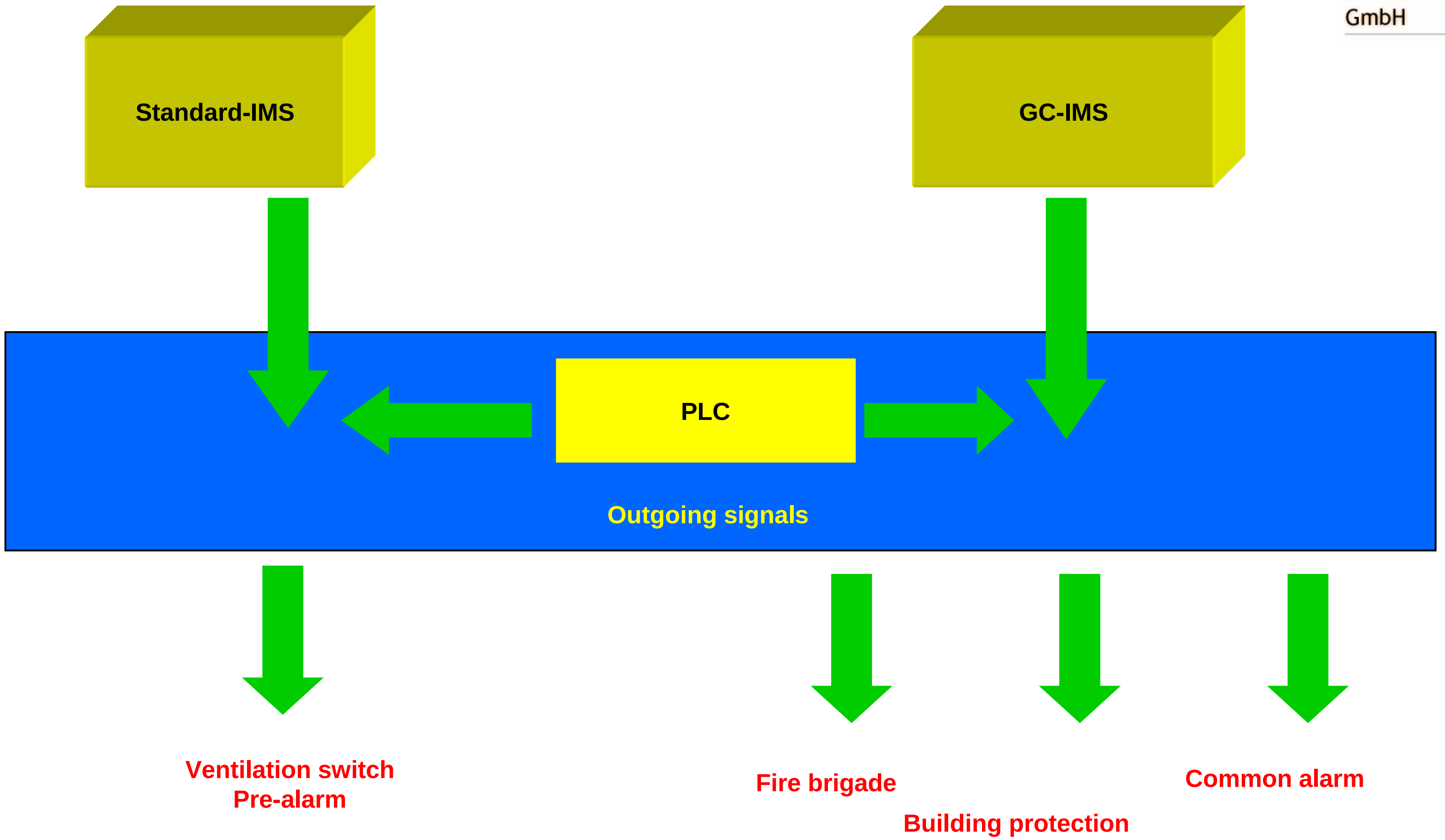
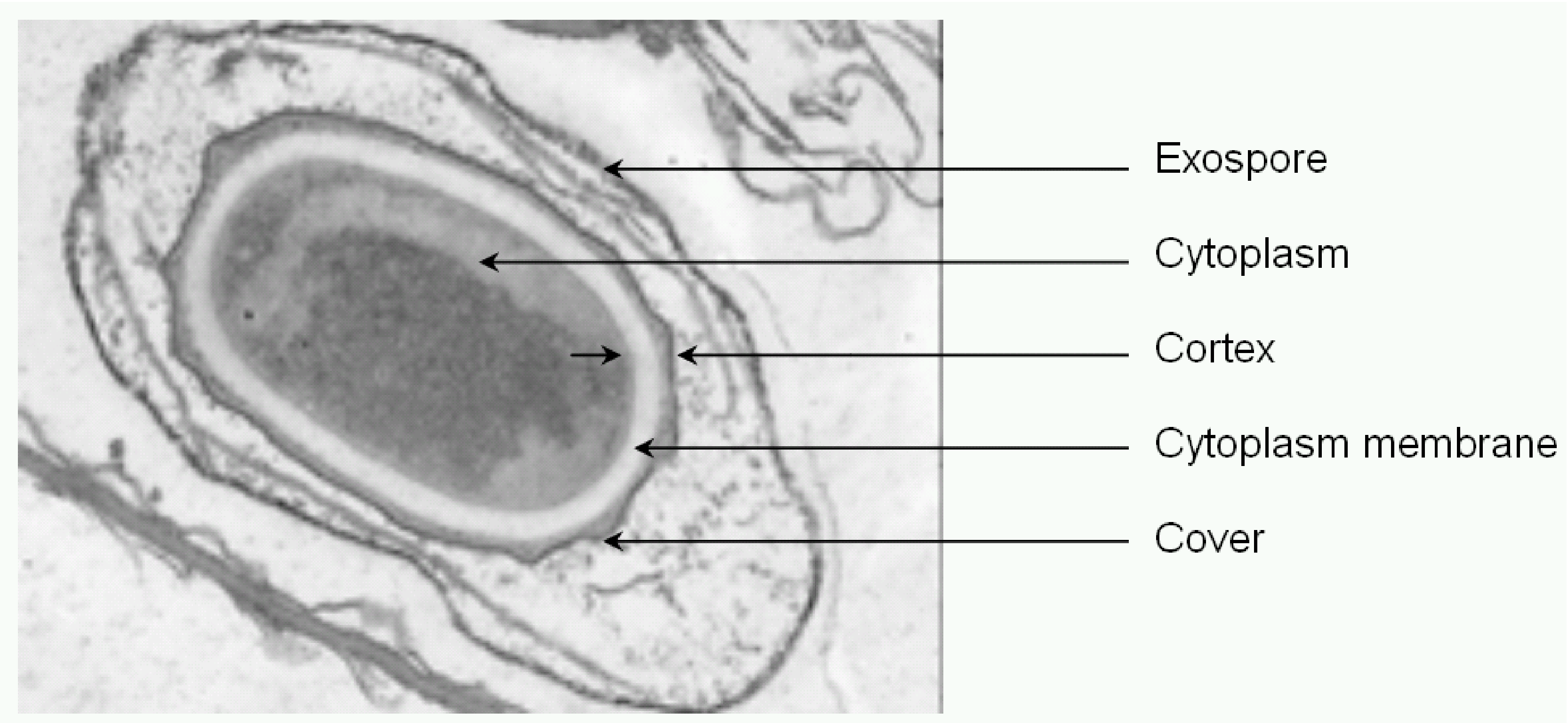
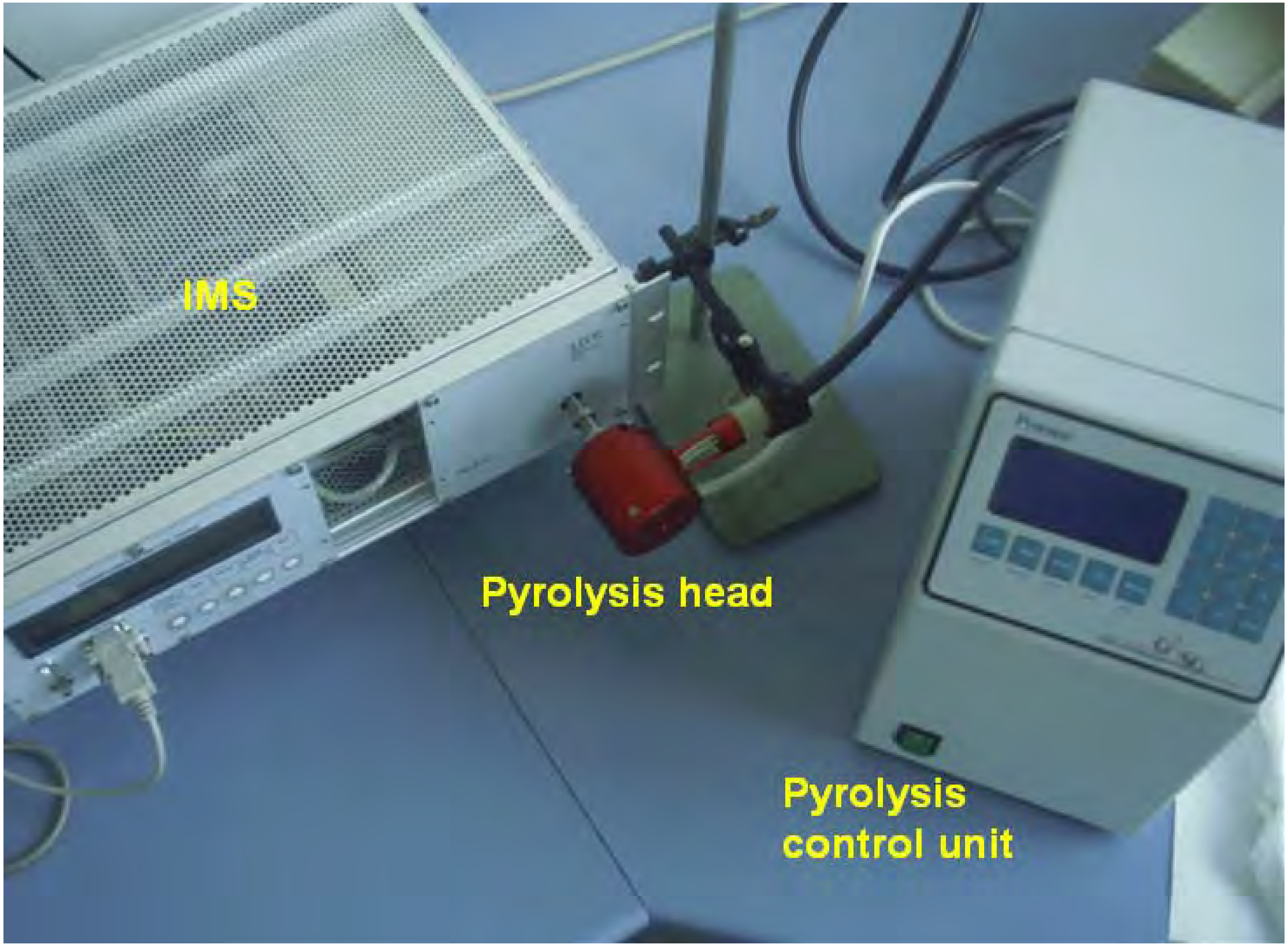



Standard-IMS
GC-IMS
PLC
Outgoing signals
Ventilation switch
Pre-alarm
Fire brigade
Building protection
Common alarm


Exospore
Cytoplasm
Cortex
Cytoplasm membrane
Cover


IMS
Pyrolysis head
Pyrolysis
control unit

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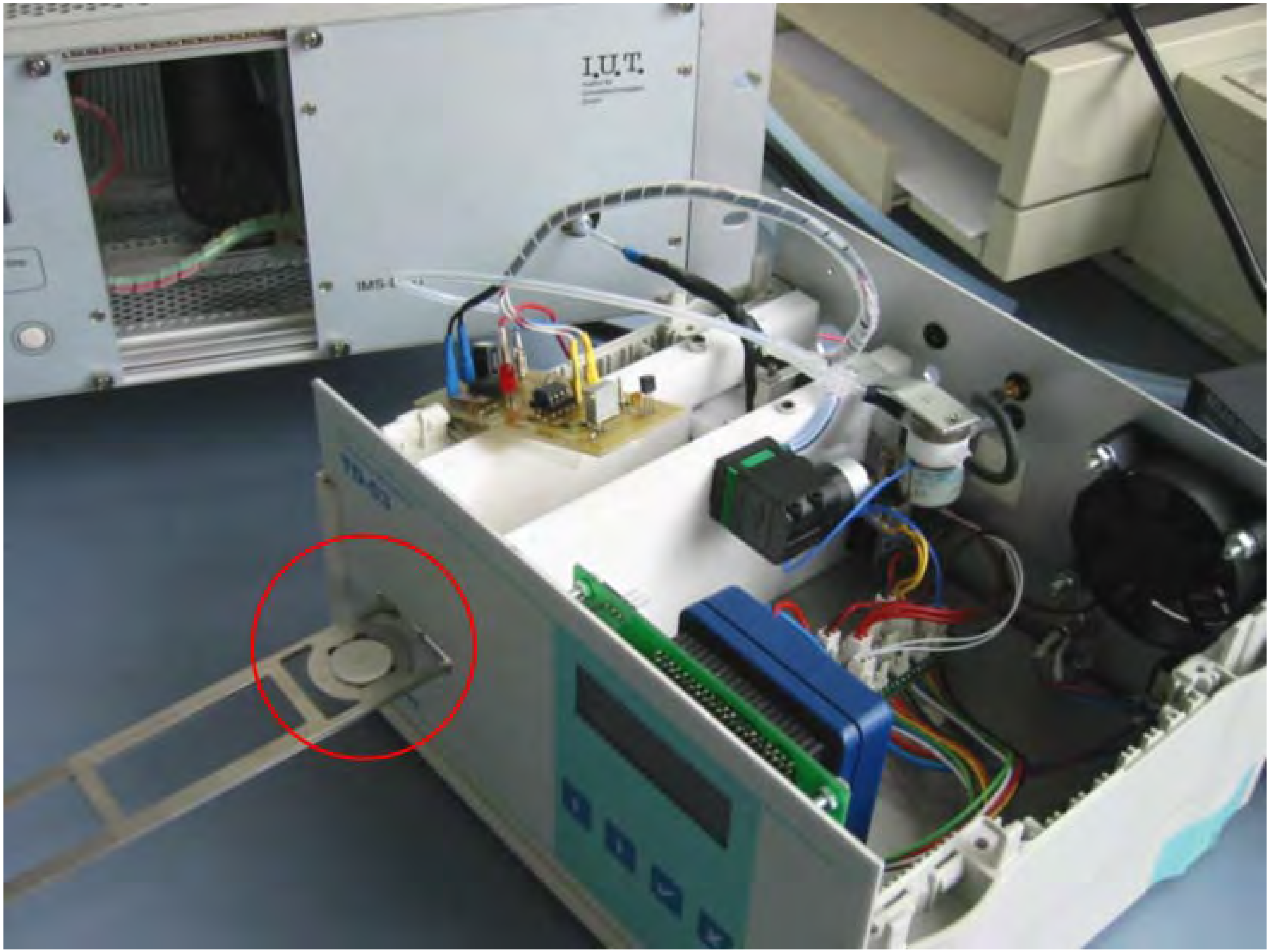
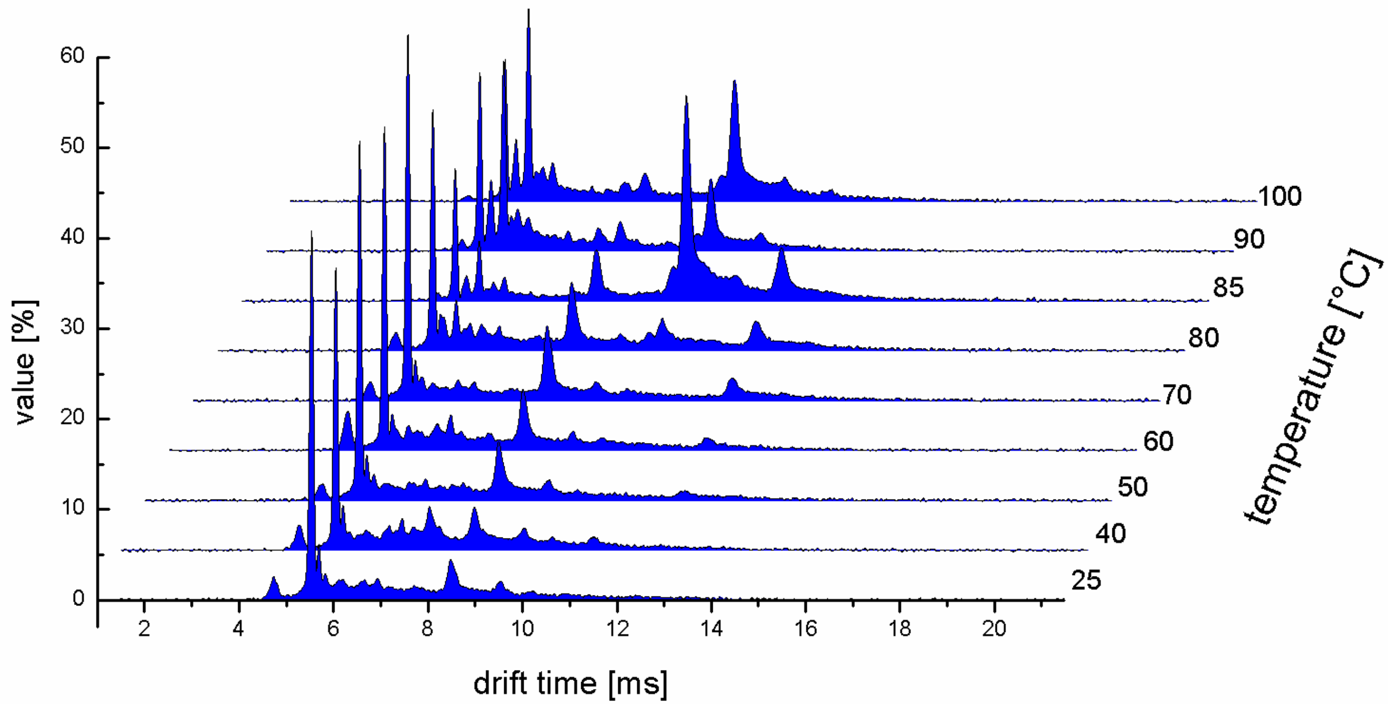
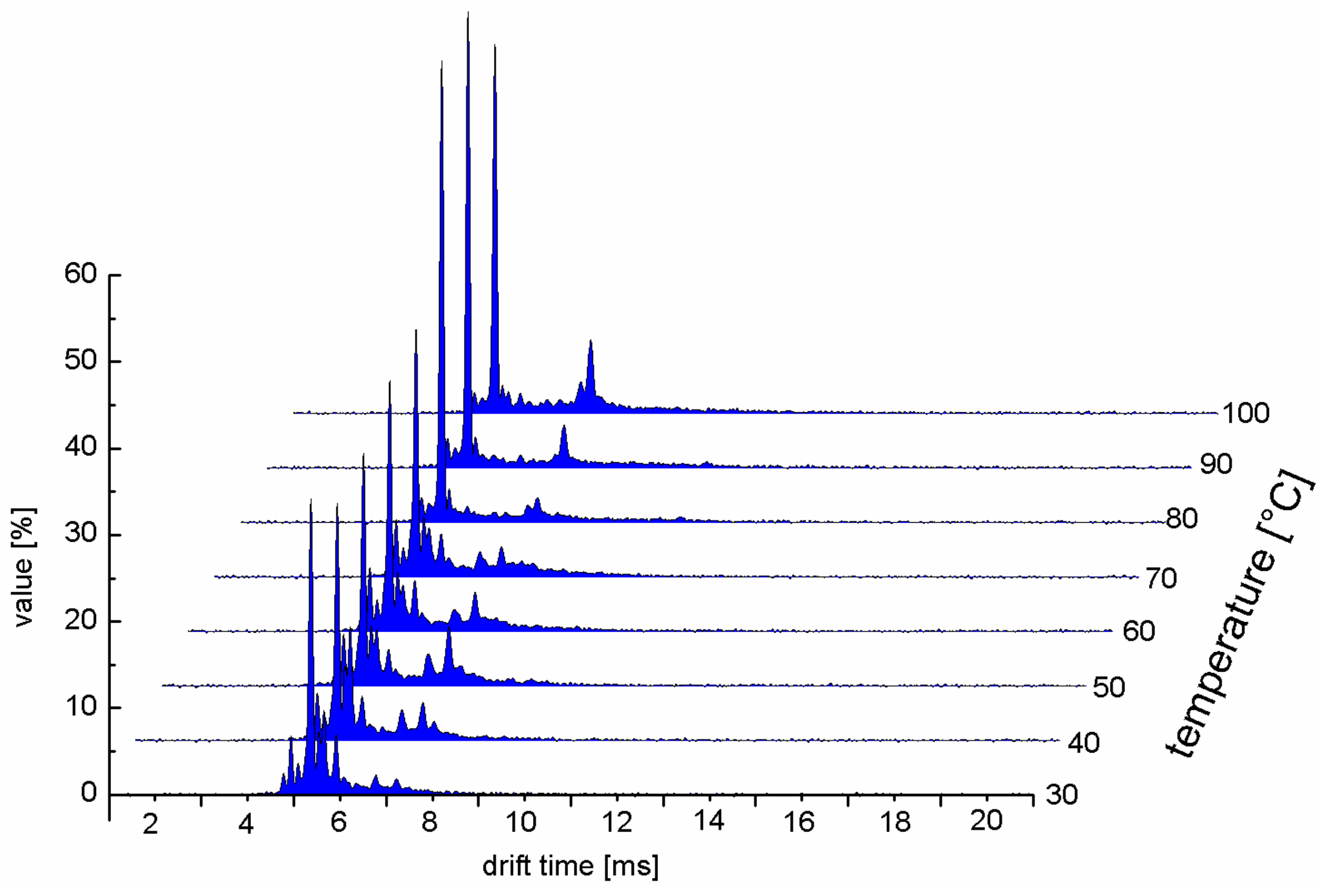


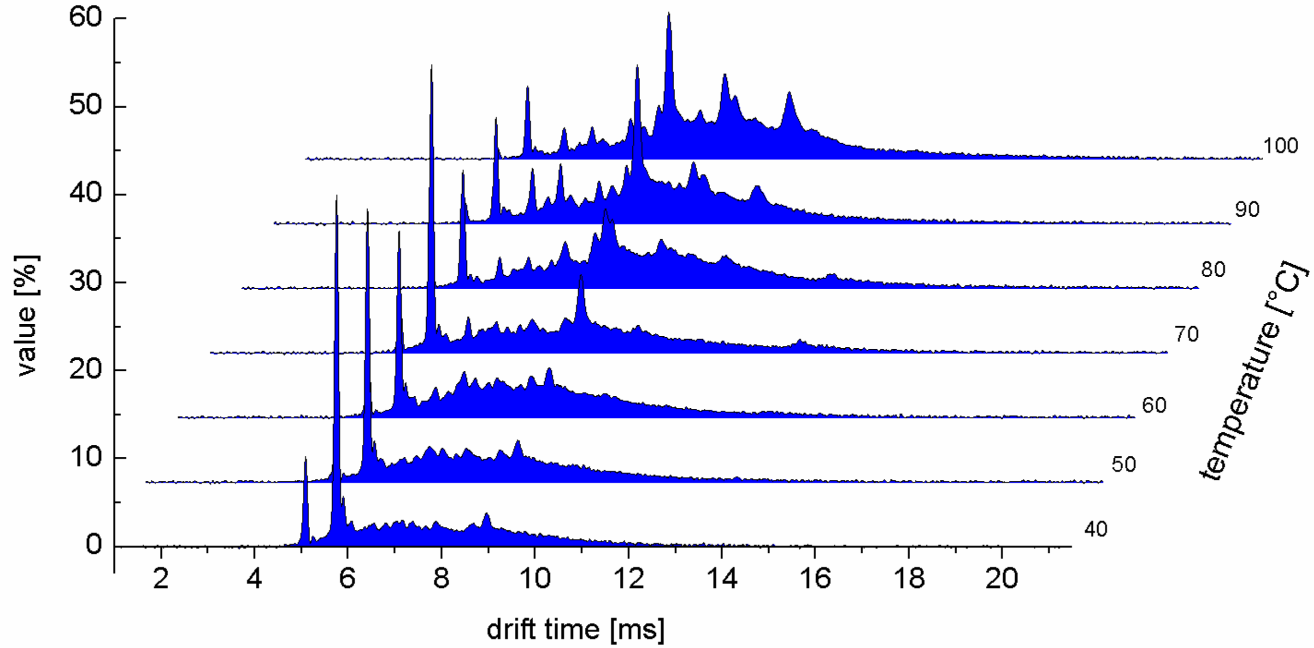
PA spectrum in the positive mode at temperature up to100°c.10 peaks are detected.



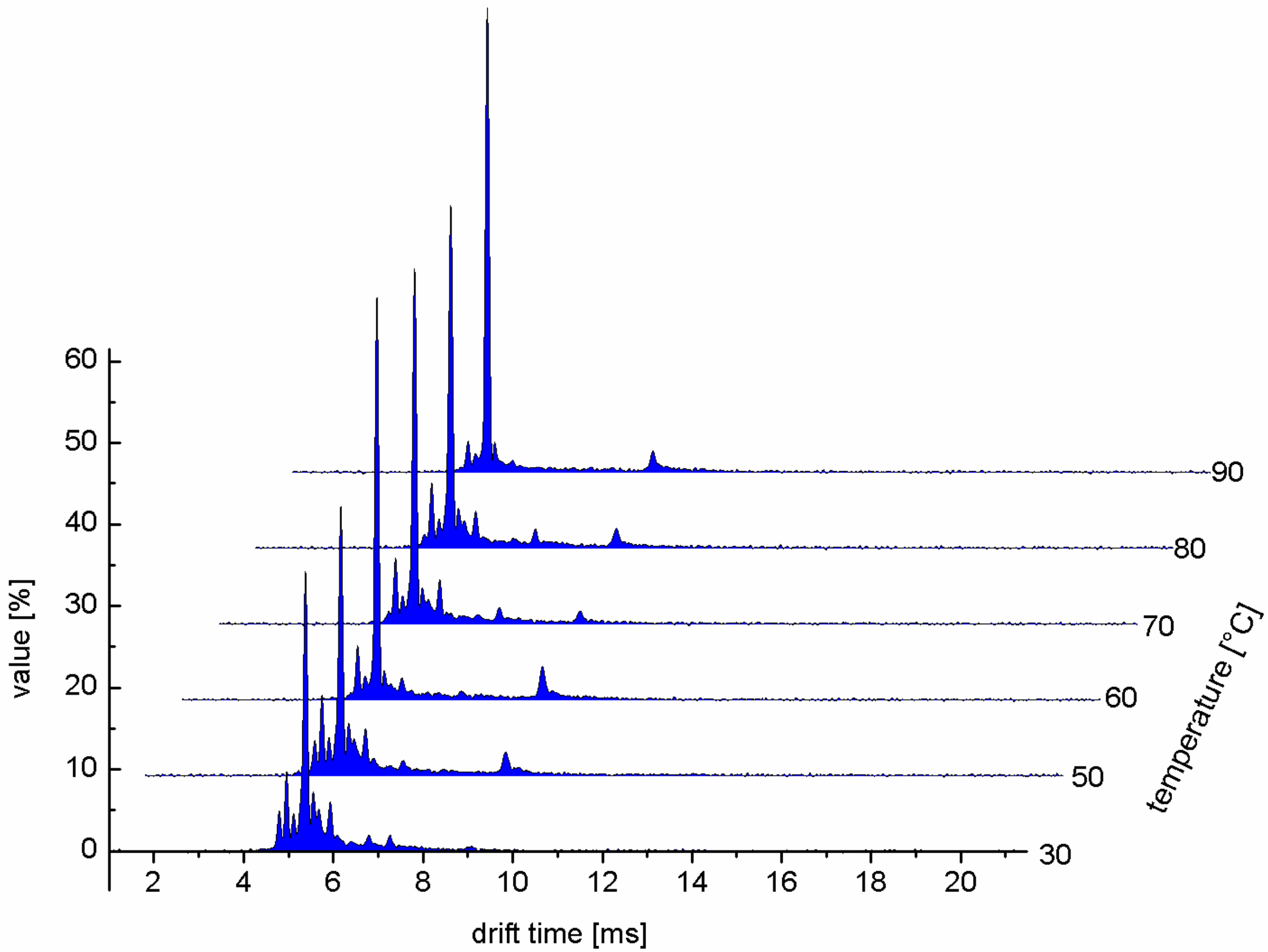
PA spectrum in the negative mode as function of temperature.



DPA spectrum in the positive mode in dependence on temperature

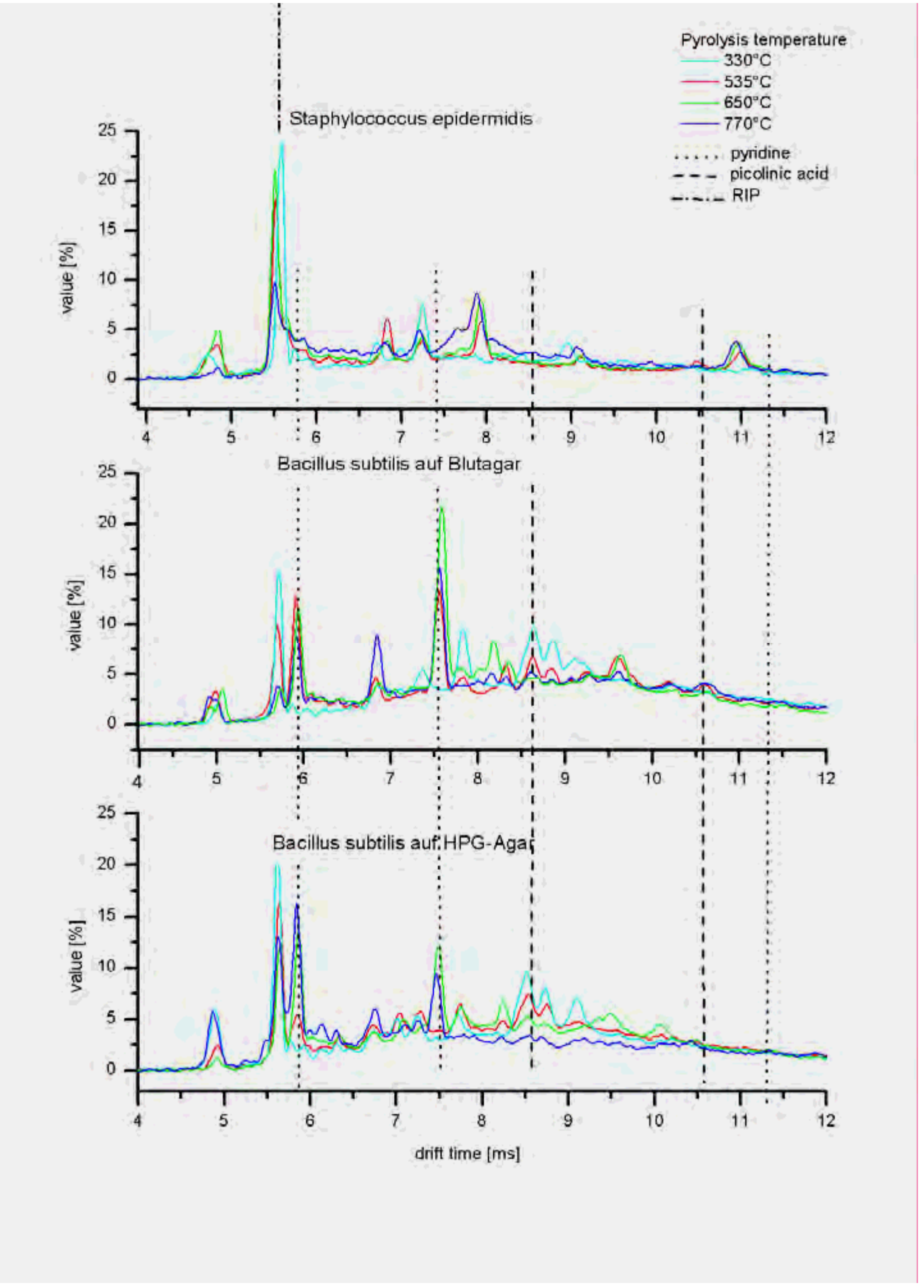


DPA spectrum in the negative mode in dependence on temperature



	K_0 in cm^2/Vs (experimental)		K_0- in cm^2/Vs (literature)	
	positive	negative	positive	reference
Pyridine - Monomer	1,932	-	2,21	Eiceman, 1994
Pyridine - Dimer	1,510	-	-	
Pyridine - Trimer	0,990	-	-	
Picolinic acid - Monomer	1,336	1,685	1,80	Snyder, 1999
Picolinic acid – destruction	1,087	1,573	-	
Picolinic acid - Dimer	0,915	1,530	1,46	Snyder, 1999
Dipicolinic acid	1,302	1,260	-	

Pea	retention time in min	peak area	peak heigth	half peak width in s	%-of all	name
1	9,267	314955	196777	1,60	1,20	Pyridine
2	9,408	83731	64885	1,29	0,32	Unknown
3	12,192	3462132	749656	4,62	13,17	Acetic acid
4	14,050	5219225	2877140	1,81	19,86	2-Furanmethanole
5	14,858	4353875	2038481	2,14	16,57	Acetamide
6	16,525	135986	52759	2,58	0,52	Unknown
7	19,325	960474	217930	4,41	3,65	2-Hydroxypyridine
8	20,592	3145658	1325559	2,37	11,97	Aziridine
9	21,433	1481562	662737	2,24	5,64	Pentadecan acid
10	21,600	3904906	1798910	2,17	14,86	Hexadecan acid
11	22,992	983810	342998	2,87	3,74	Isopropylpalmitate
12	23,892	1375179	420716	3,27	5,23	Heptadecan acid
13	24,333	860050	160633	5,35	3,27	Niacinamide



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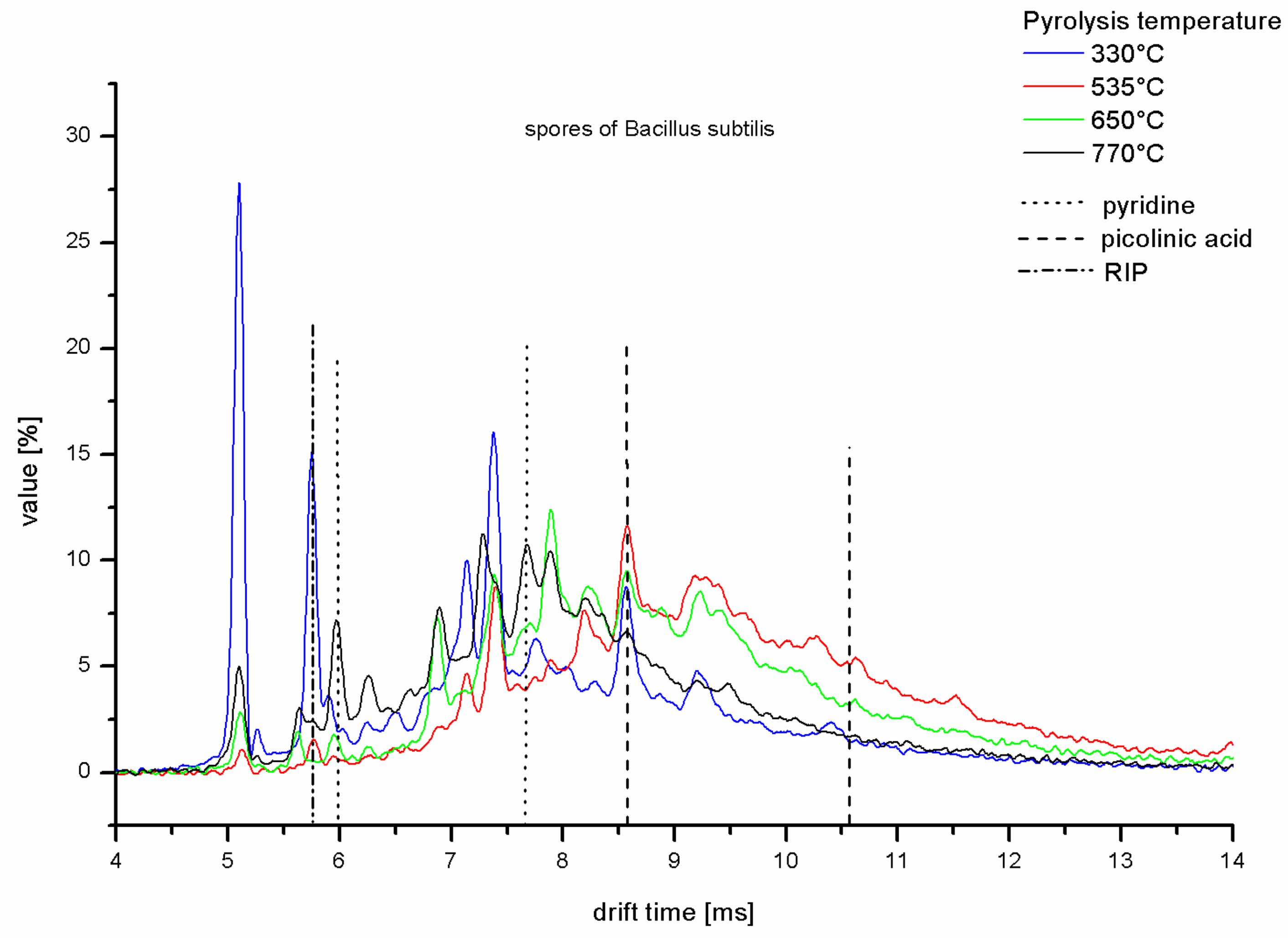

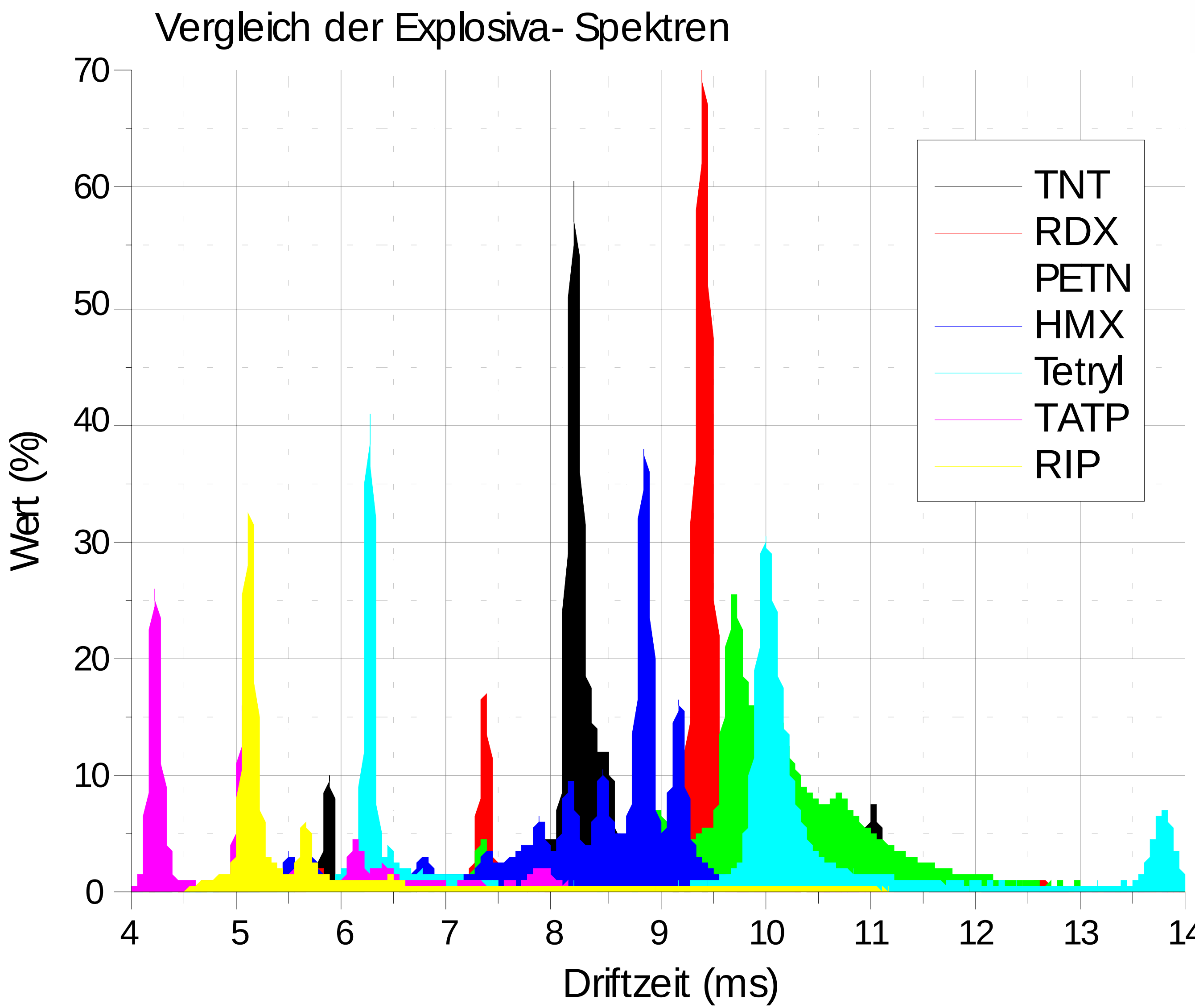

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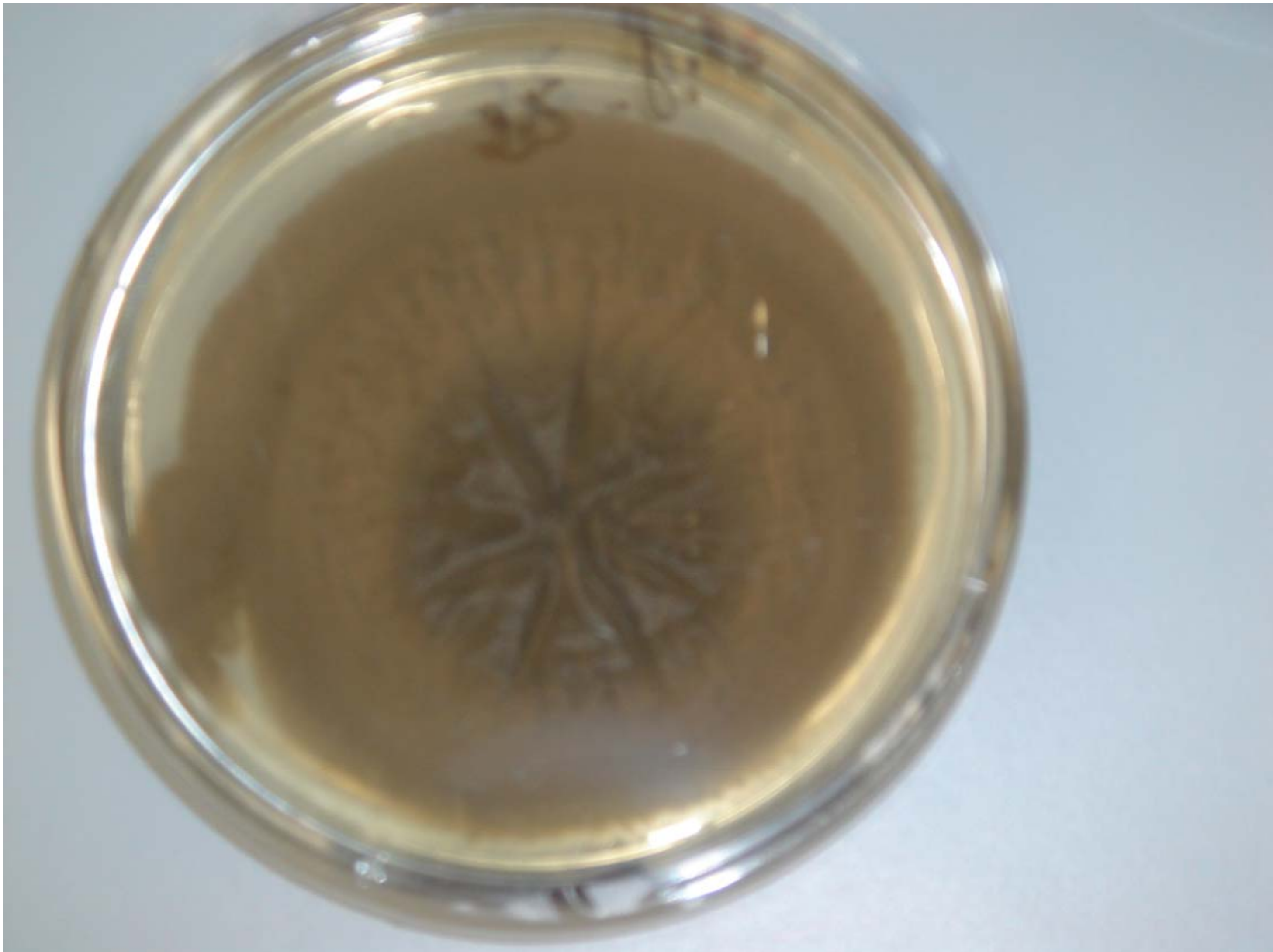
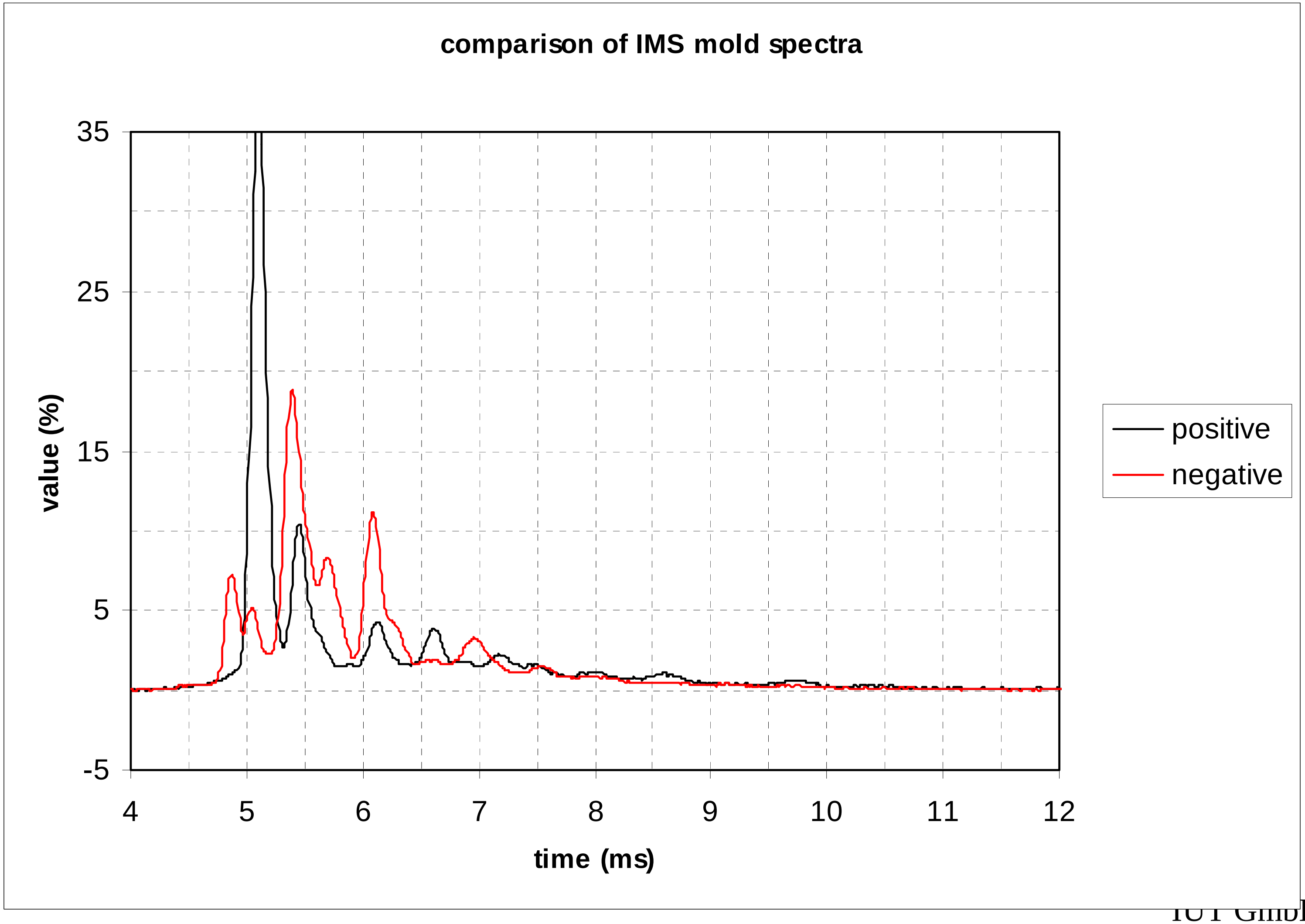


+/- Spectra of a mold culture



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NEUTROTEST- A NEUTRON BASED NONDESTRUCTIVE DEVICE FOR EXPLOSIVE DETECTION

by Dr. Jürgen Leonhardt

26 October 2005

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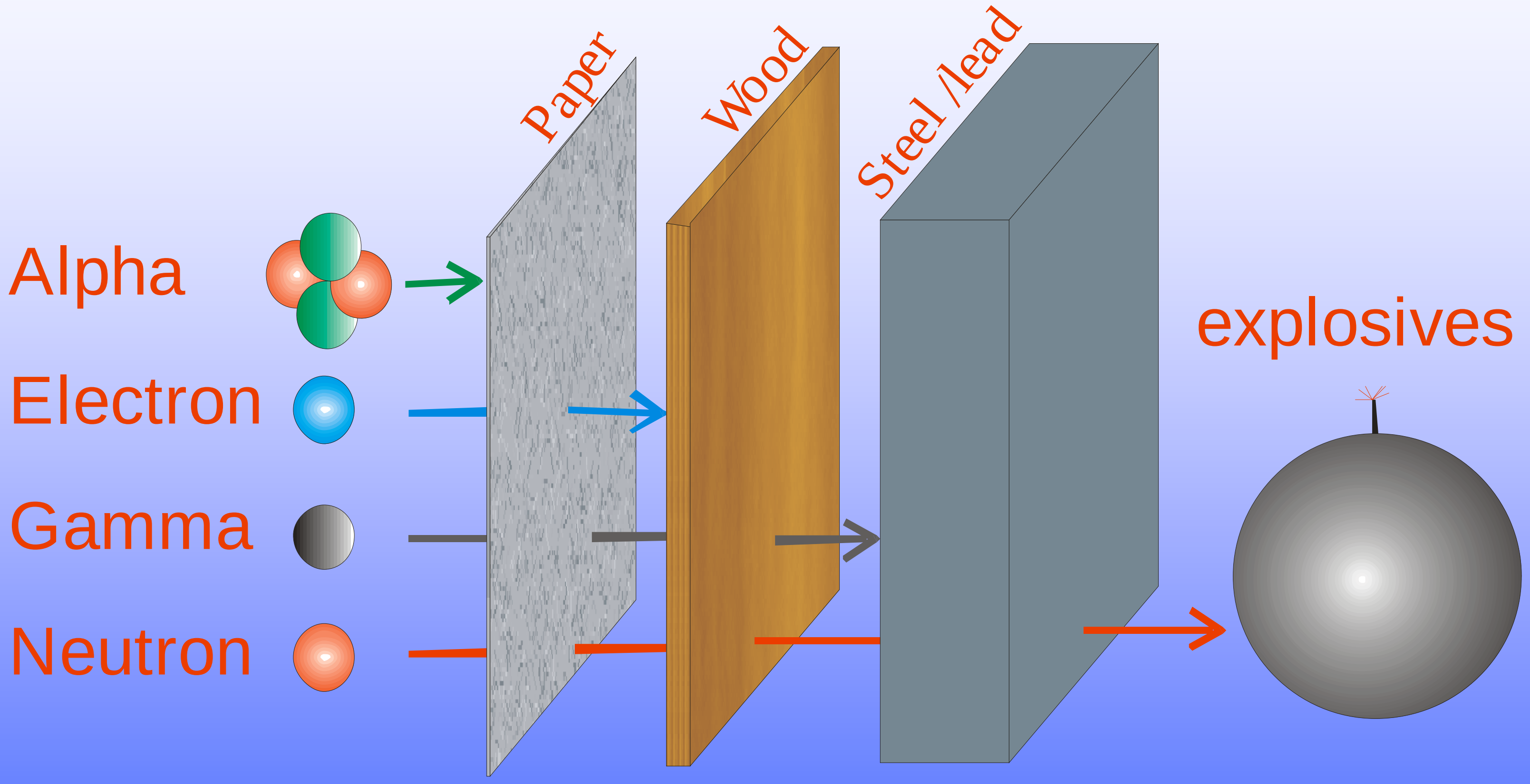
www.isonics.com

The problem

Detecting hidden storage of explosives devices and explosives is a complicated problem, particularly in view of the development of plastic casings and plastic explosives

→ Solution: **Neutron-based devices**

Advantage of neutrons



Since neutrons are able to penetrate several mm of steel and lead, they are particularly suitable for the detection of hidden materials.

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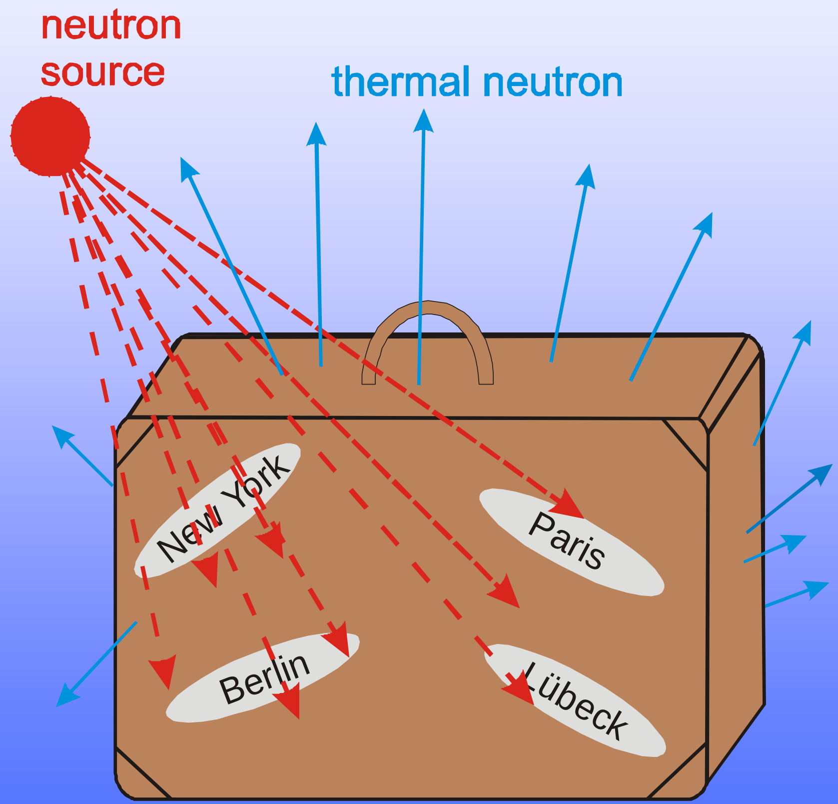
NeutroTest: The principle

- Explosives and drugs consist of light elements like:
  - **hydrogen (H)**
  - **carbon (C)**
  - **oxygen (O)**
  - **nitrogen (N)**

- → **hydrogen** is able to thermalize and backscatter fast neutrons

NeutroTest: The principle



Fast neutrons generated by the neutron source irradiate the object, where they are slowed down (thermalized) and backscattered by the light elements.

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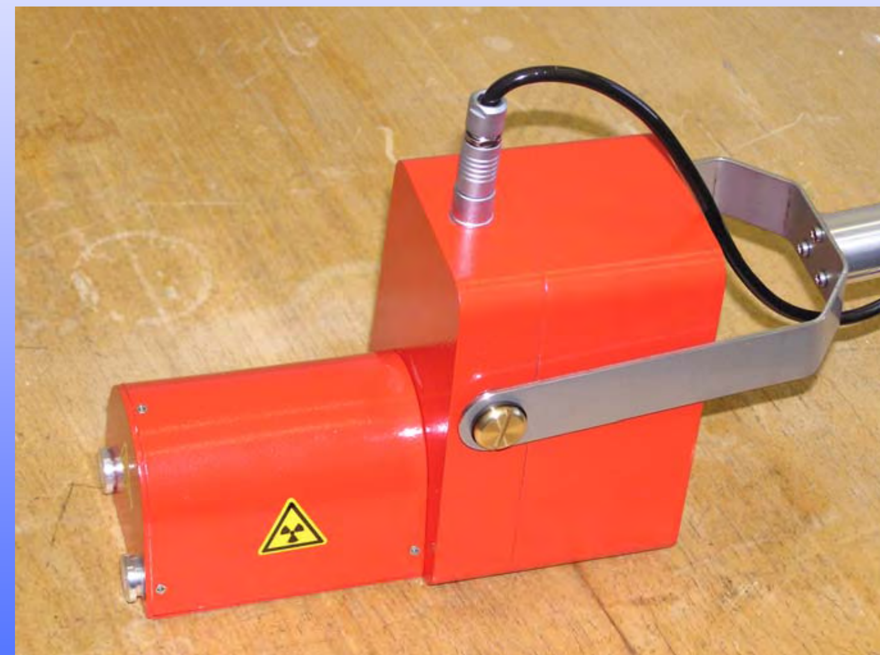
NeutroTest

NeutroTest 0



NeutroTest 1

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A suitcase filled with lab coats (cotton), Pb tube and pieces of paraffin and TNT

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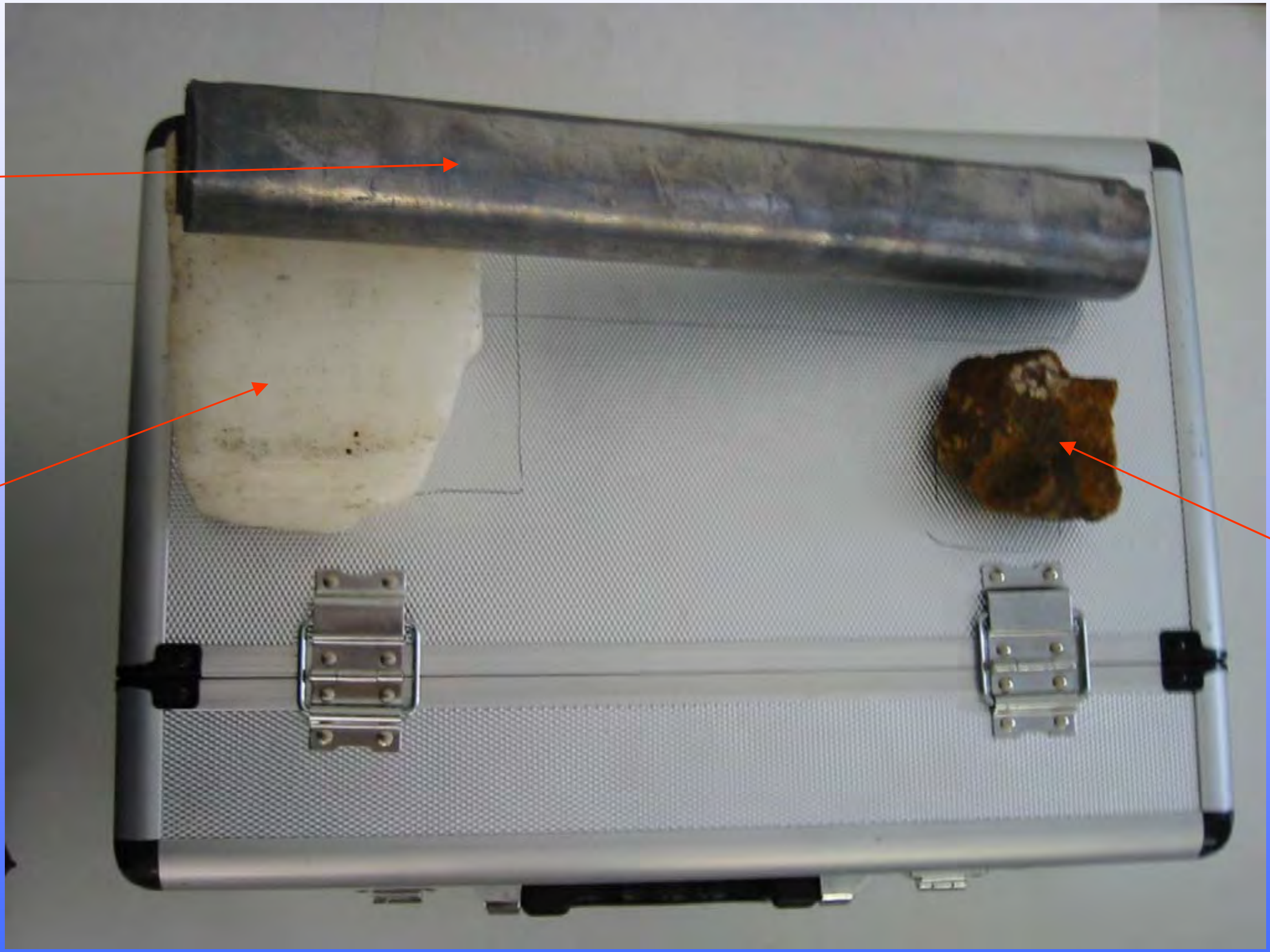
The paraffin and TNT have different hydrogen contents, Pb tube has no H

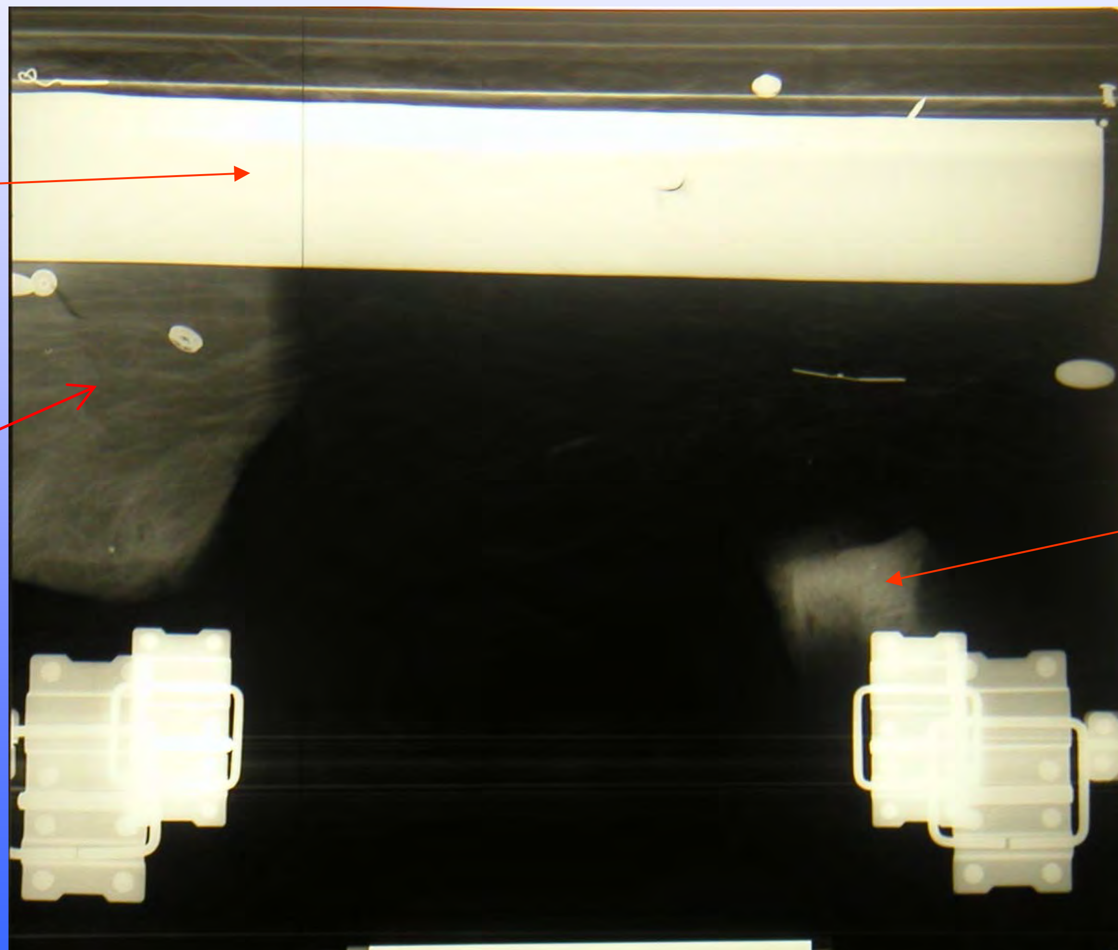
Lead tube

Paraffin



TNT

The X-ray of the suitcase shows a density distribution, TNT is difficult to identify



Lead tube

Paraffin

TNT

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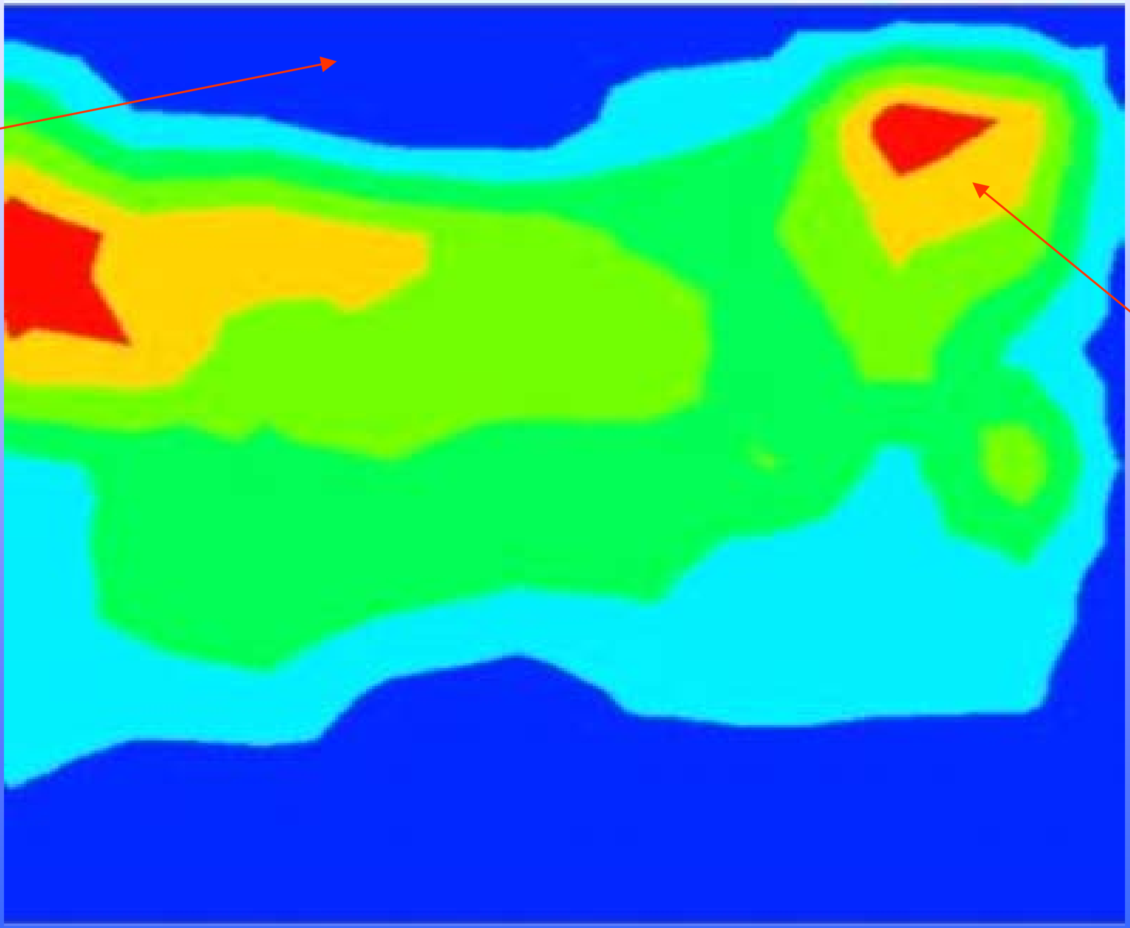
Protonogramm of the suitcase

produced by thermalized neutrons-backscattered

Lead
tube

Paraffin



TNT

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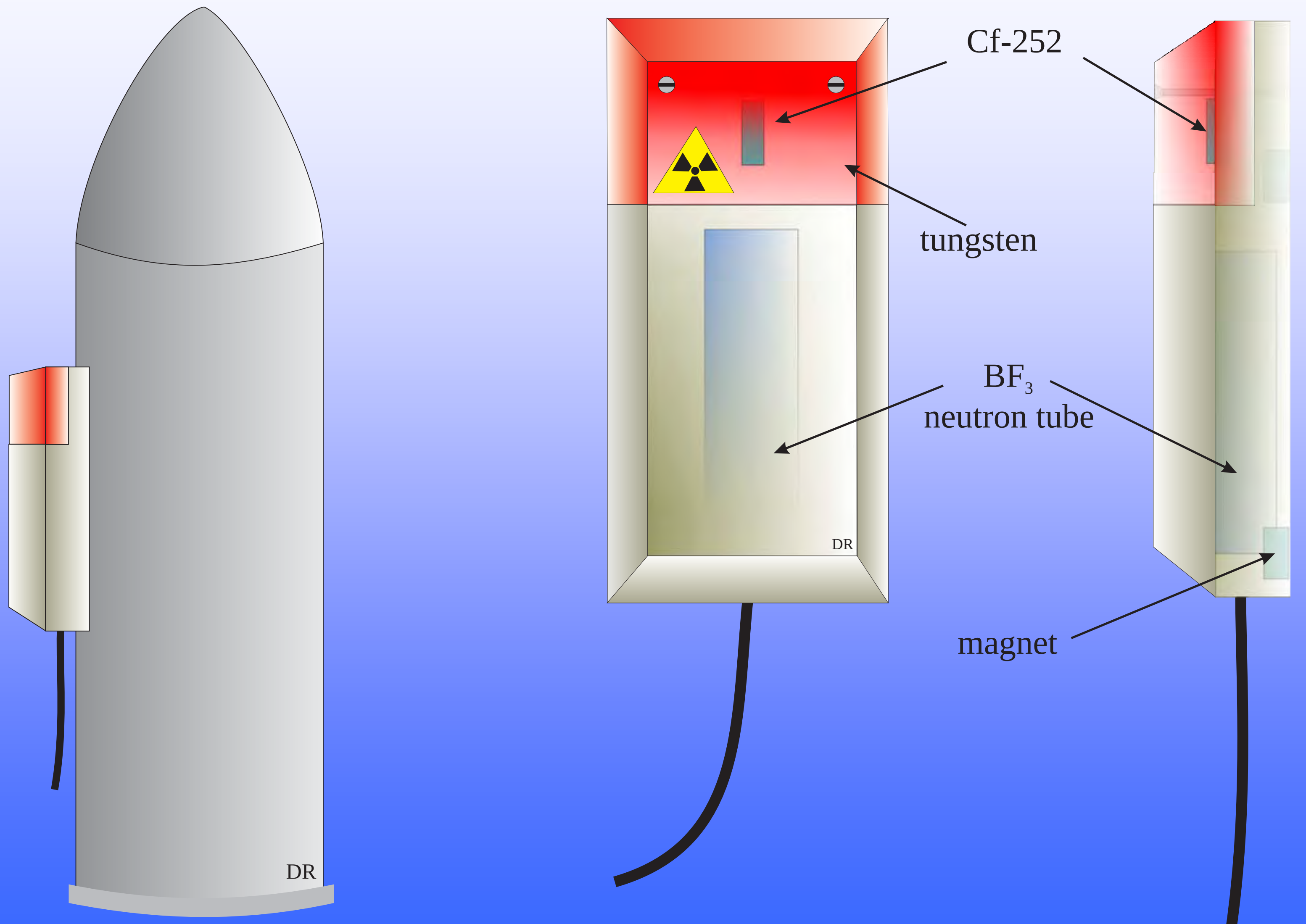
NeutroTest
shell/bomb identifier



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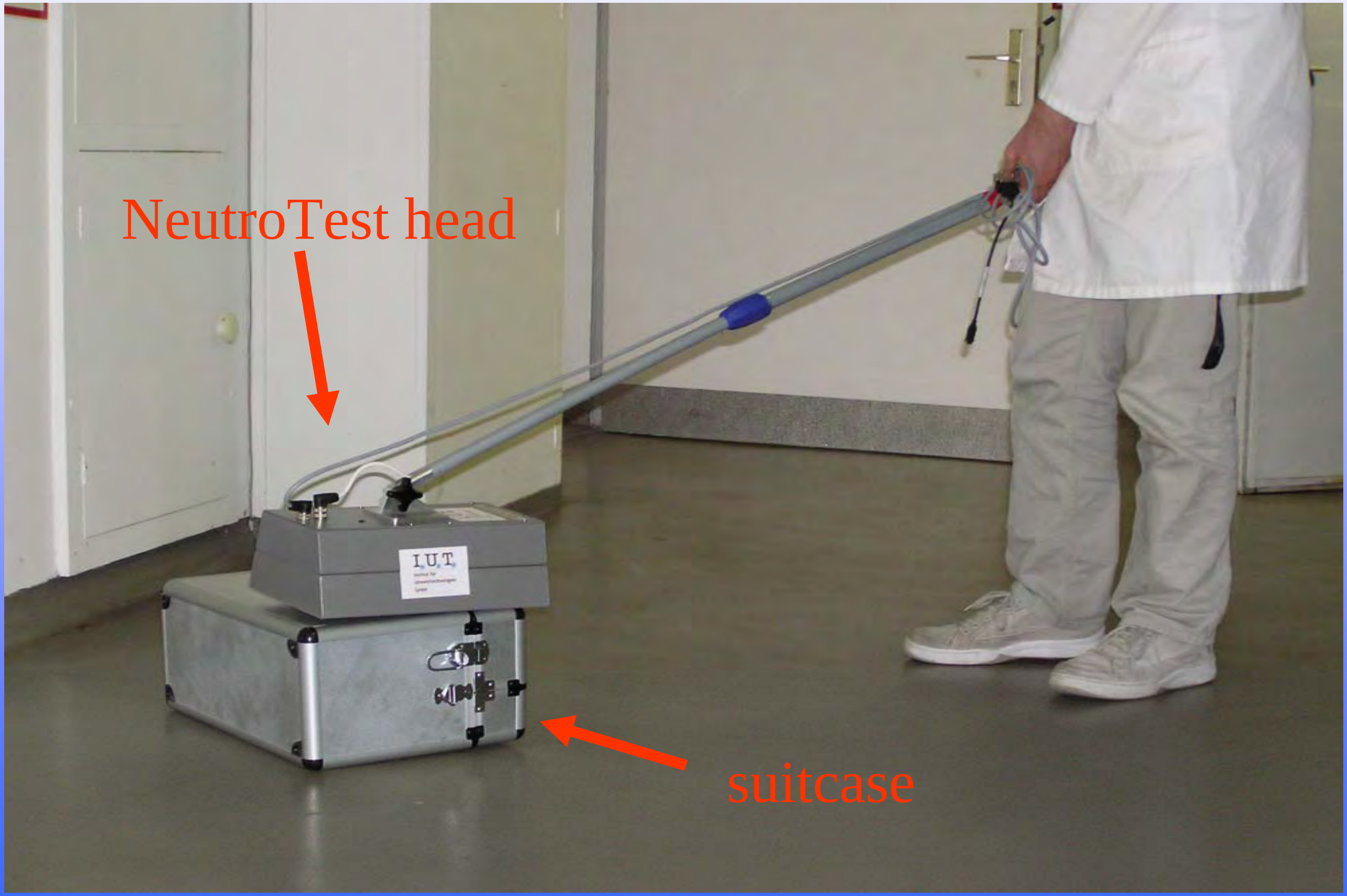
NeutroTest 0 Prototype



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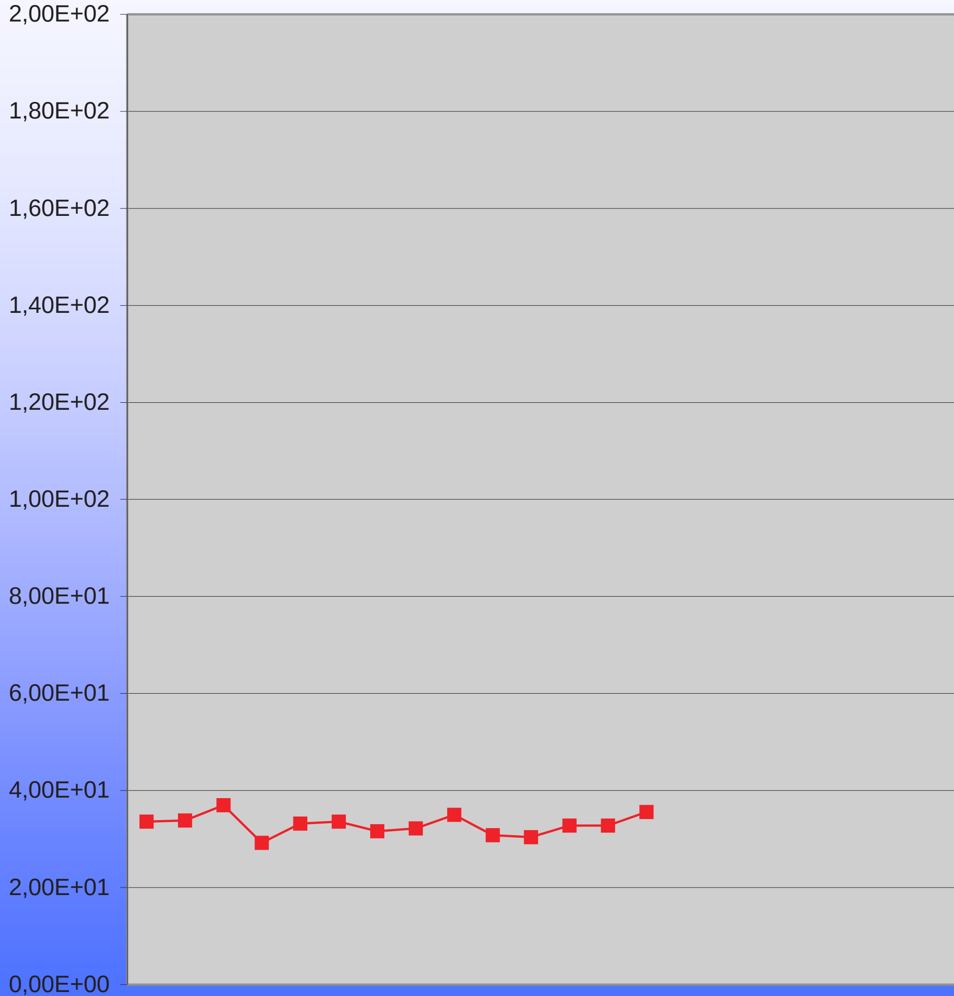
Field trial NT 0: melting kettle for TNT (WW2)



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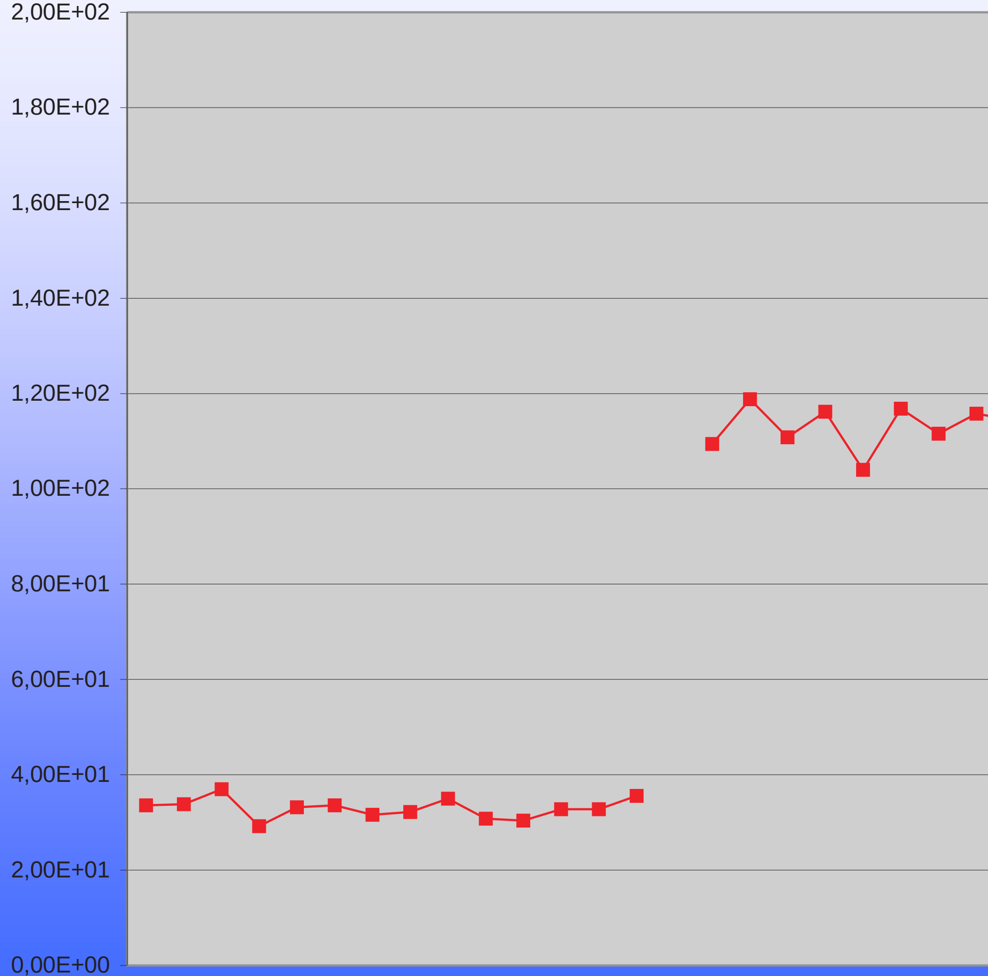
Field trial NT 0:
melting kettle for TNT (WW2)



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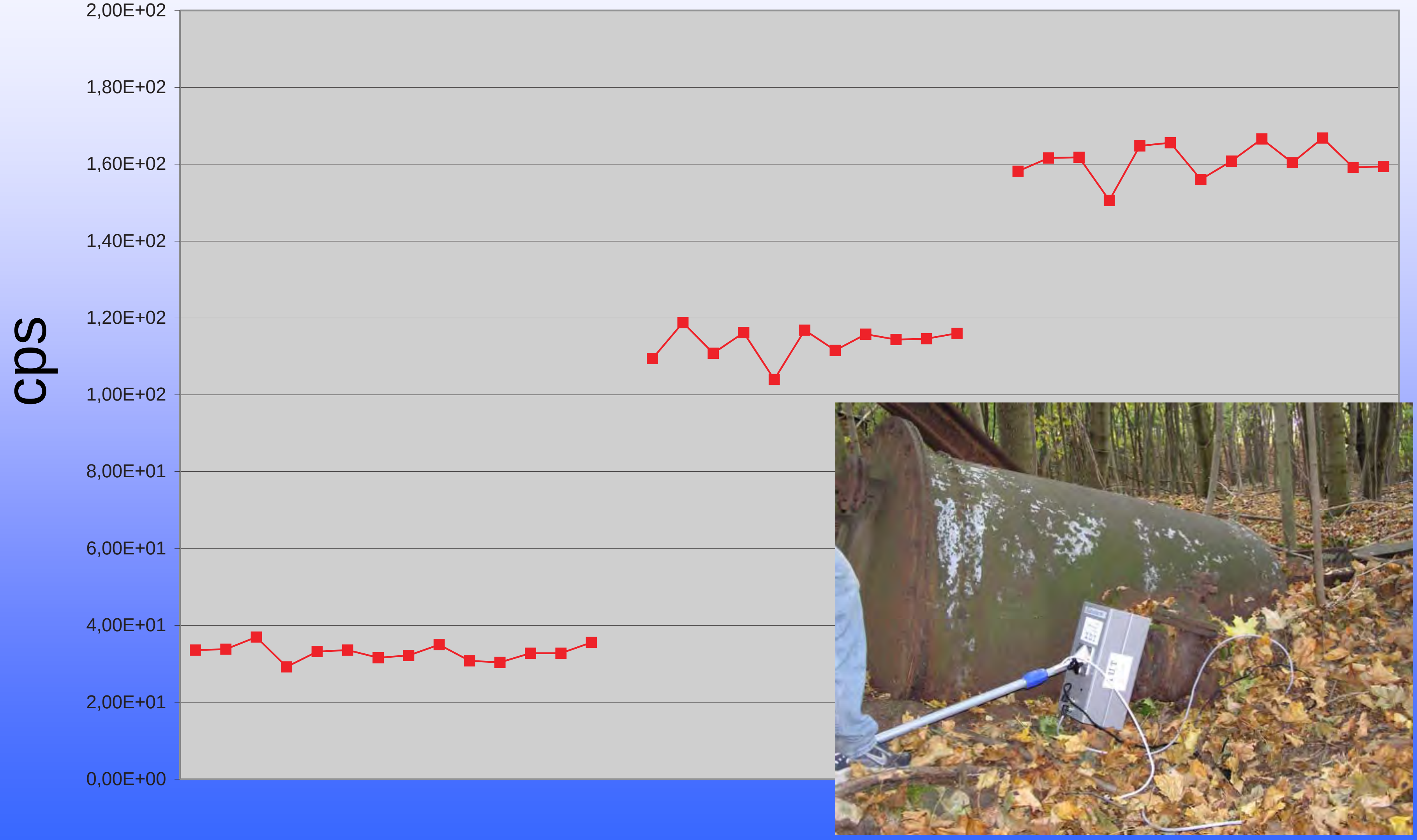
Field trial NT 0: melting kettle for TNT (WW2)



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Valve filled with TNT (WW2)

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Scanning of a box with NT 0

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Box filled with DNT (WW2)

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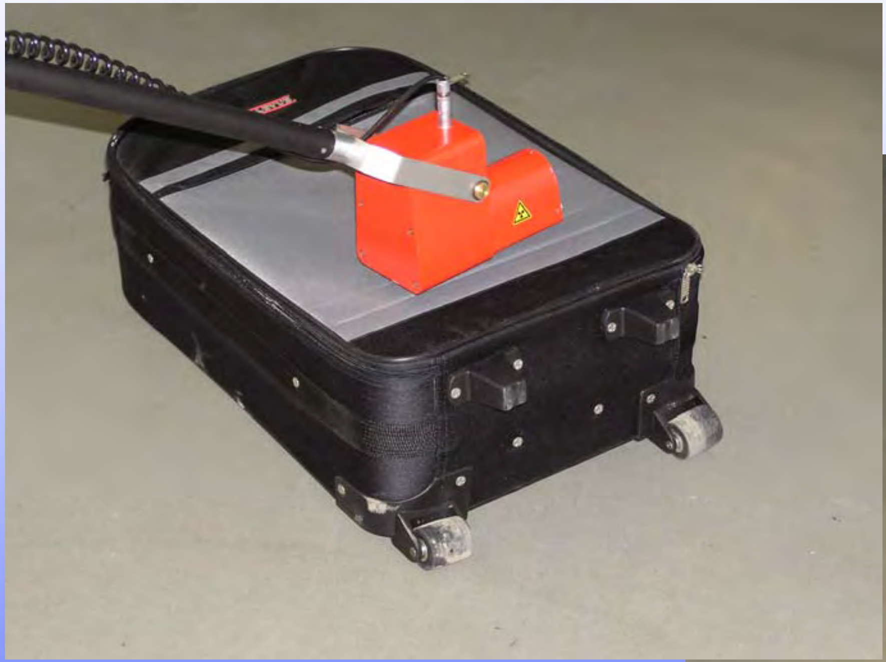
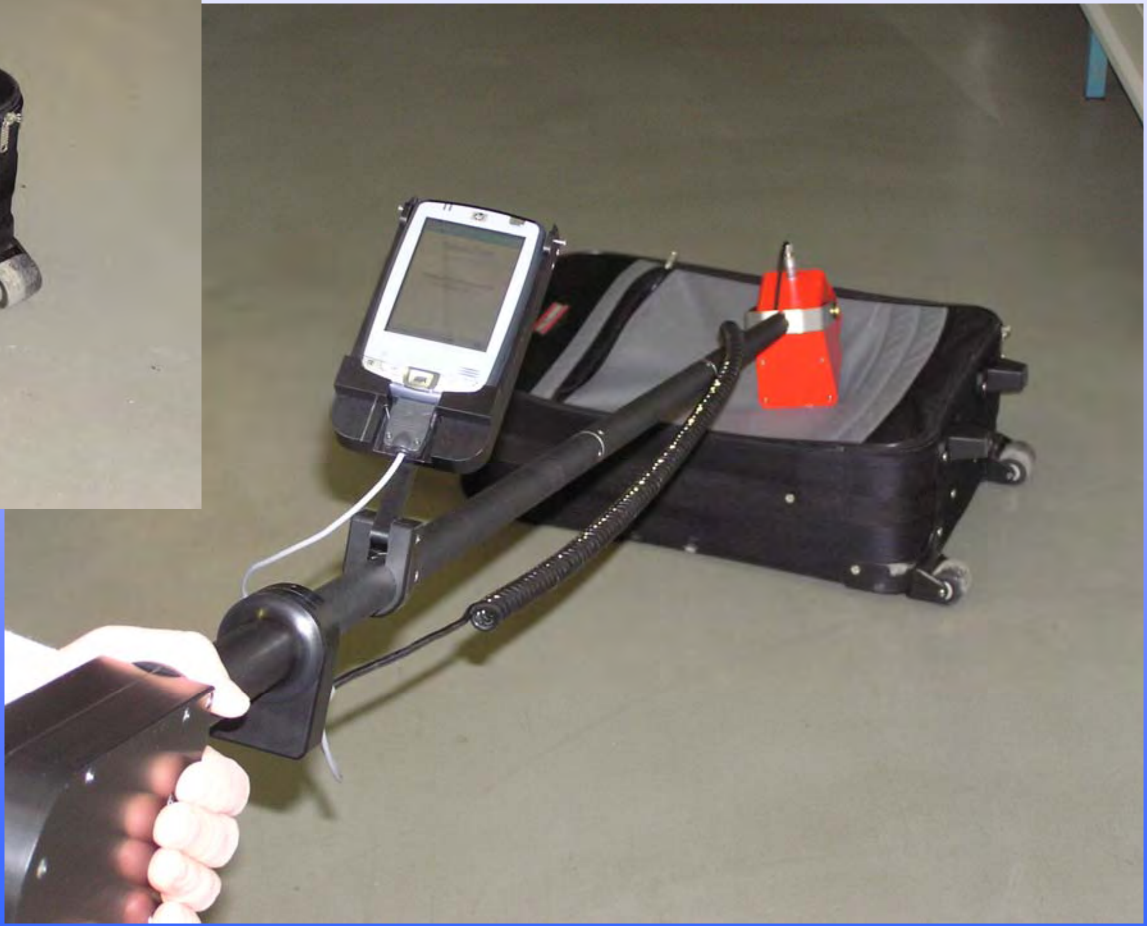
Suitcase scan with NeutroTest 1





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CAR INSPECTION BY NT1

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Identification of booby traps by NT1

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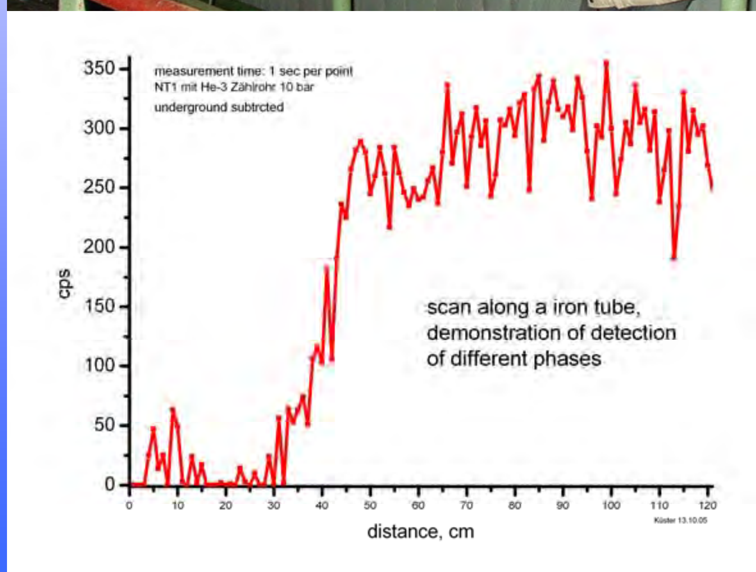
DETERMINATION OF FILLING HEIGHT IN TUBES



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Field scanning with NeutroTest 1

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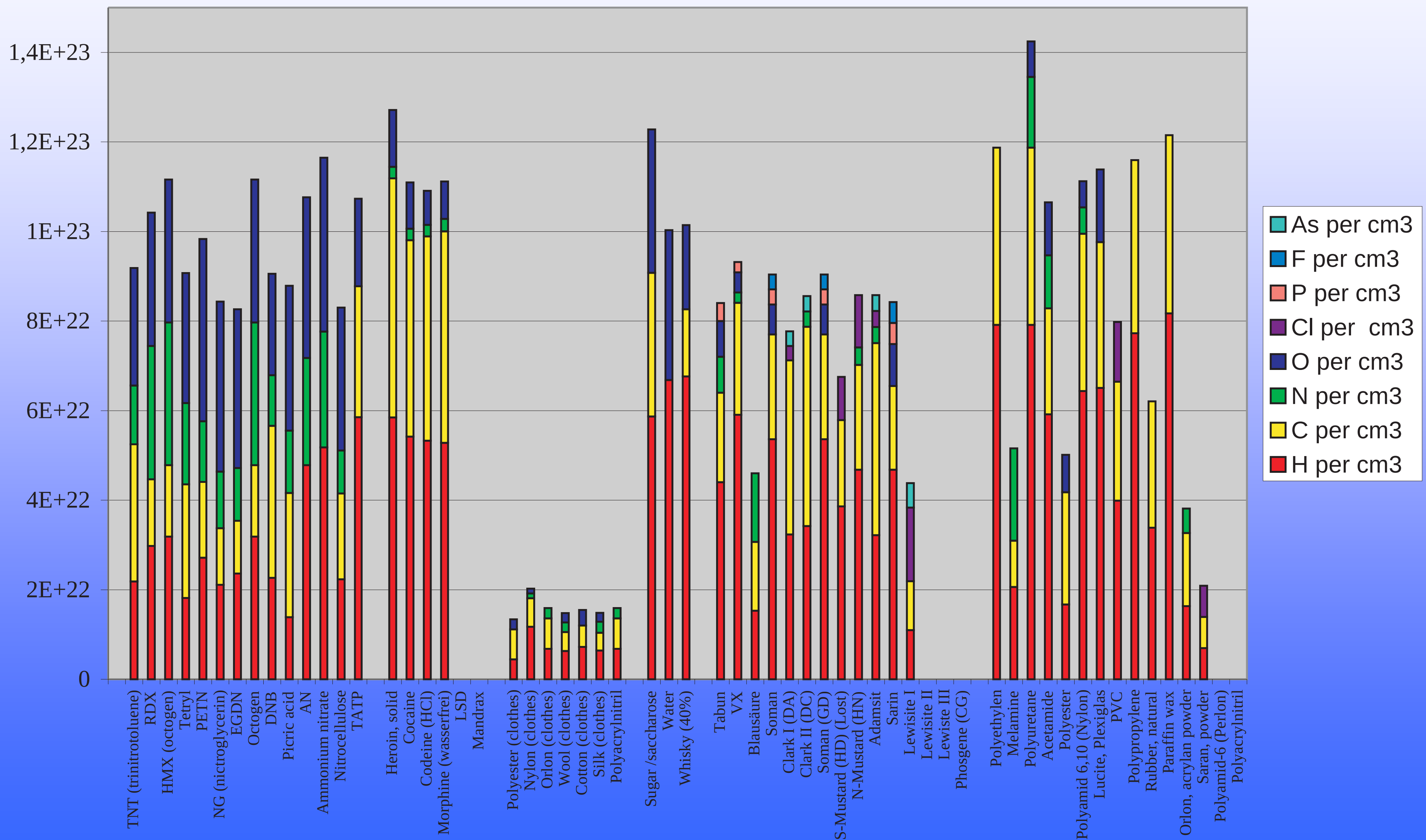
Element density (total)



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Problem of a counting rate based system

Problem:

counting rate dependes on: distance source-object $1/r^2$
distance object-detector $1/r^2$
weight of the object
density of the object

Based on cps:

A piece of TNT in the top part of a suitcase gives the same signal as a much bigger piece of water in the bottom.

The geometry factors have to be cancelled out

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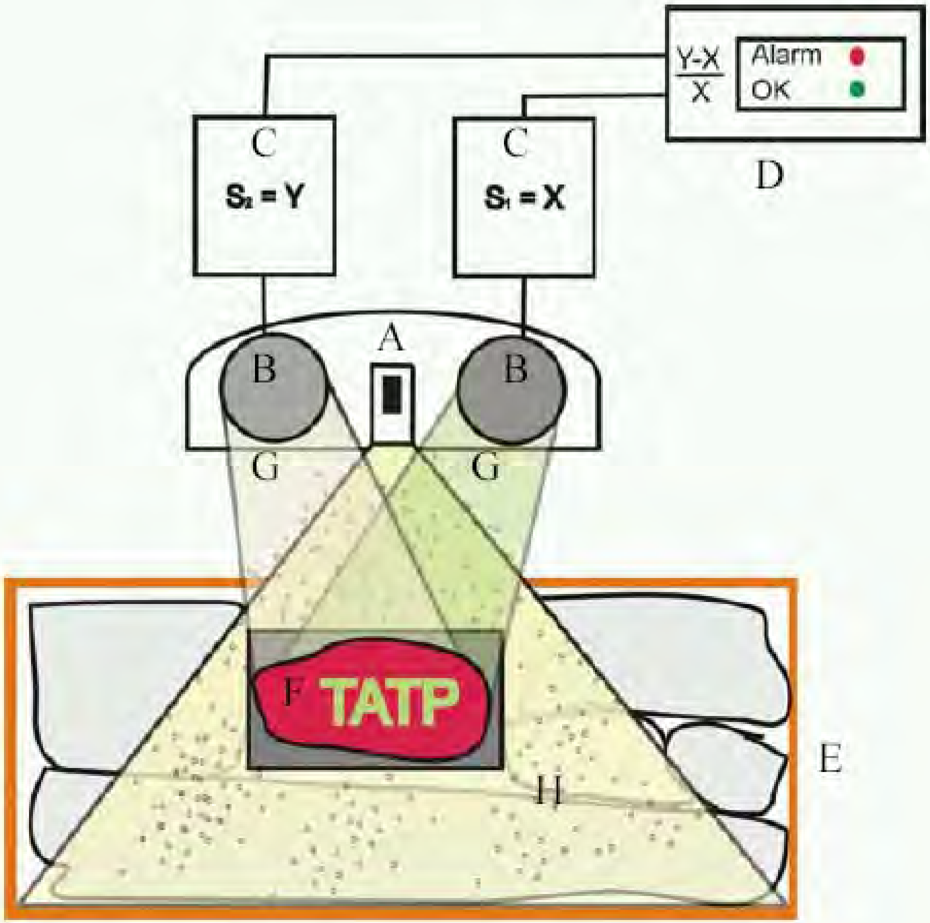
SCHEME OF NEUTROTEST2



A) Neutron source / Cf-252 - 10^6n/sec
B) Neutron gauges
C) Electronic unit
D) Microcontroller, display
E) Hand luggage
F) Explosive in steel container
G) Backscattered neutrons
H) Flux of fast neutrons

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Ratio method

Ratio = n(without Cd) / n(with Cd)
= thermal / fast neutrons

$$Ratio \sim \frac{N0(source) \cdot G1\_th \cdot G2\_th \cdot H\_th(Objekt)}{N0(source) \cdot G1\_fast \cdot G2\_fast \cdot H\_fast(Objekt)}$$

$$Ratio \sim \frac{H\_th(Objekt)}{H\_fast(Objekt)}$$

N0	Activity of the source
G1	Geometry factor source-object
G2	Geometry factor object-detector
H	object factor

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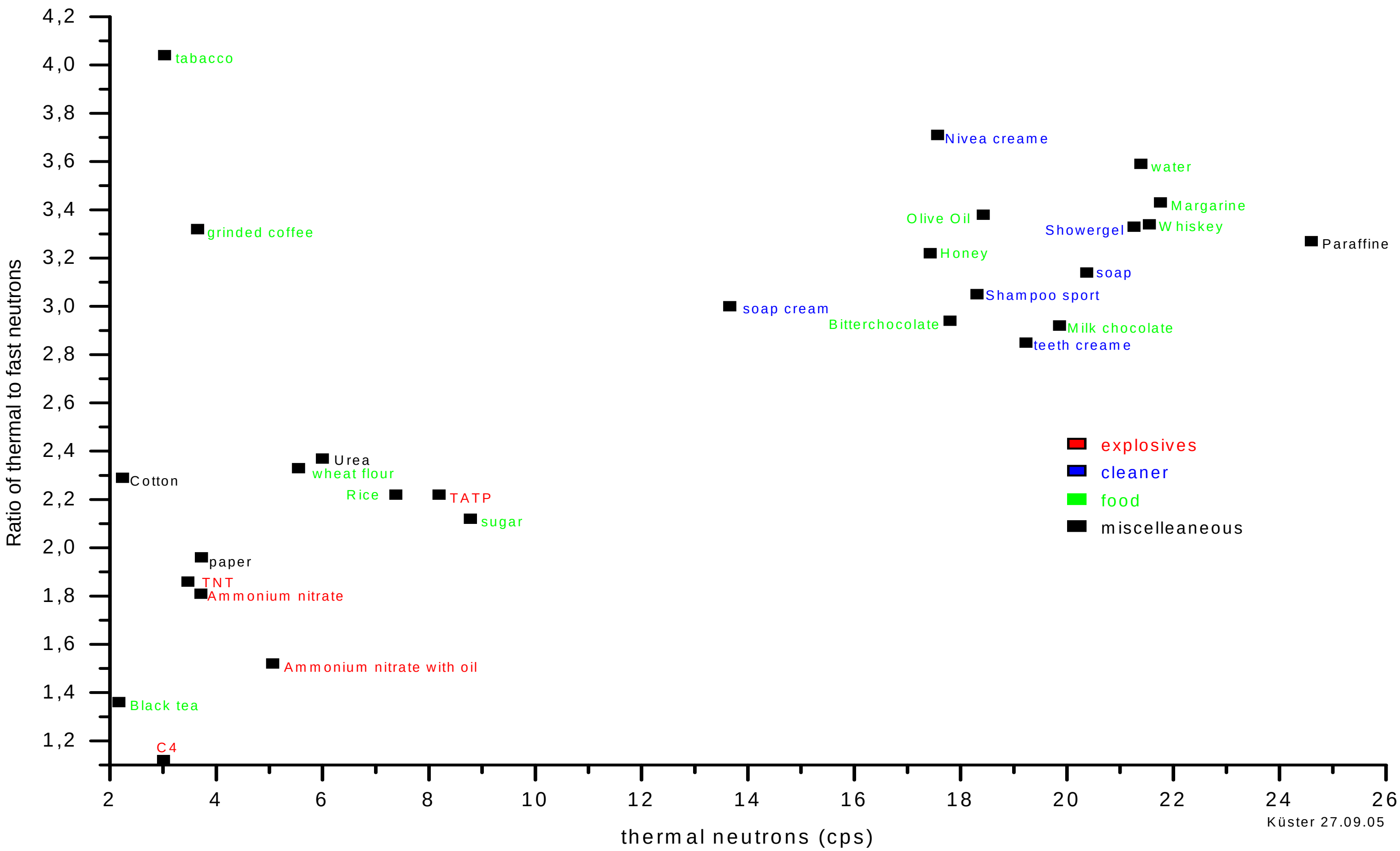
IDENTIFICATION OF EXPLOSIVES BY MEANS OF THERMAL/FAST NEUTRON RATIOS



I.U.T.
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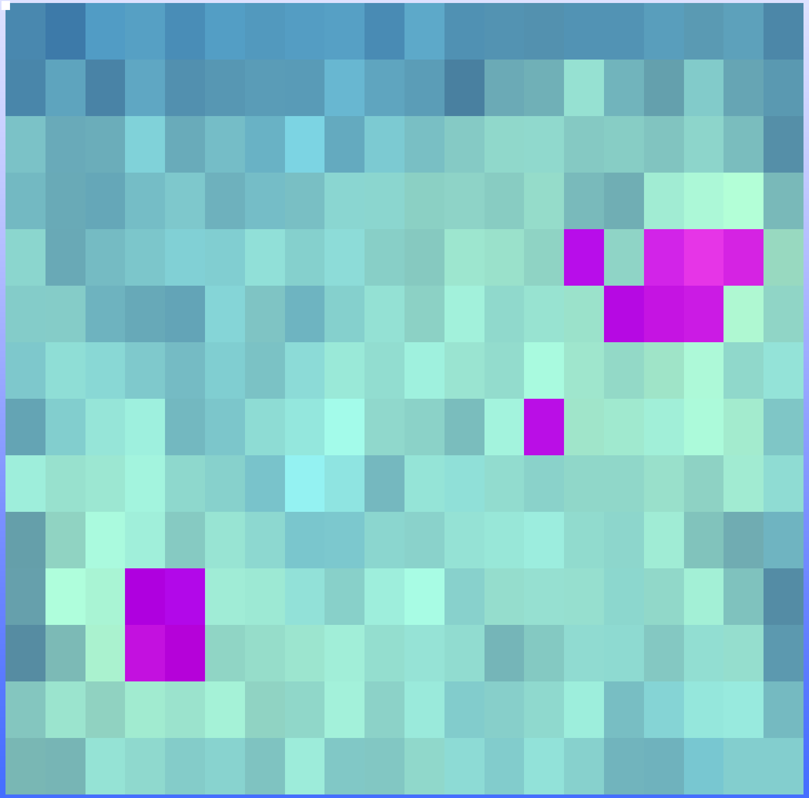
SEARCH OF EXPLOSIVE 5cm IN GROUND BY NT2



rMtf, bMff, gMqf

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NeutroTest 2

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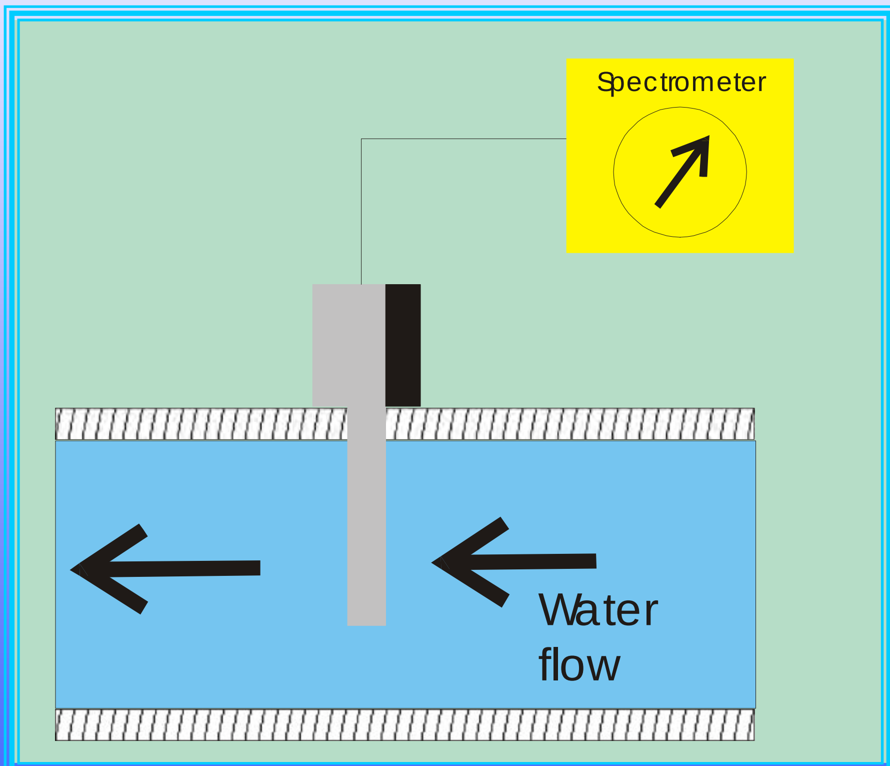
Umwelttechnologien
GmbH

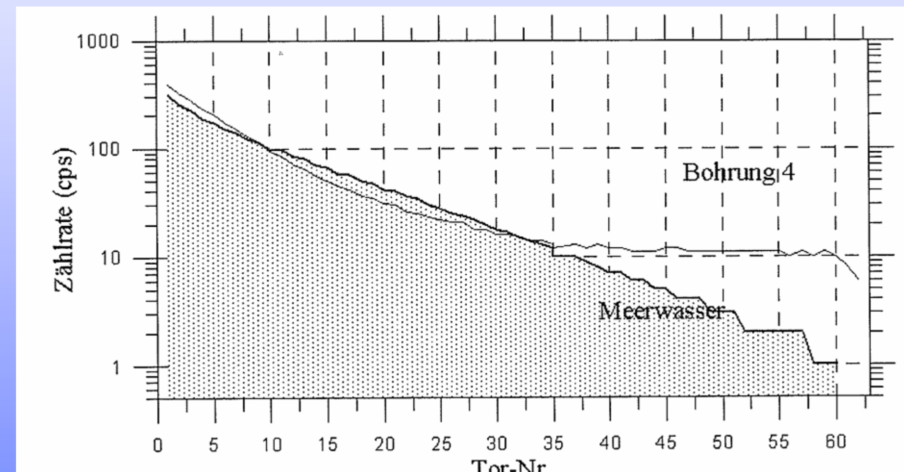
Application example

Online determination of toxic compounds in drinking water
- in boreholes - in wells - in water pipes

Scheme of the Neutroscan.



Experimental results of aromates (bencene) in seawater



Time resolved spectrum of thermal neutrons in a borhole with sea water + 6 µg Bencene per liter. Sensitive against heavy metals, organic and biological compounds.

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NEUTROSCAN EQUIPMENT

NEUTRON GENERATOR

NEUTRON GAUGE.

TUBE OF NEUTROSCAN

PRINCIPLE

Fast neutrons are produced by means of a miniaturized generator. Thermalized neutrons are detected by means of the neutron gauge. Electronic part analyze the life time distribution of thermal neutrons, which give information about toxic compounds.

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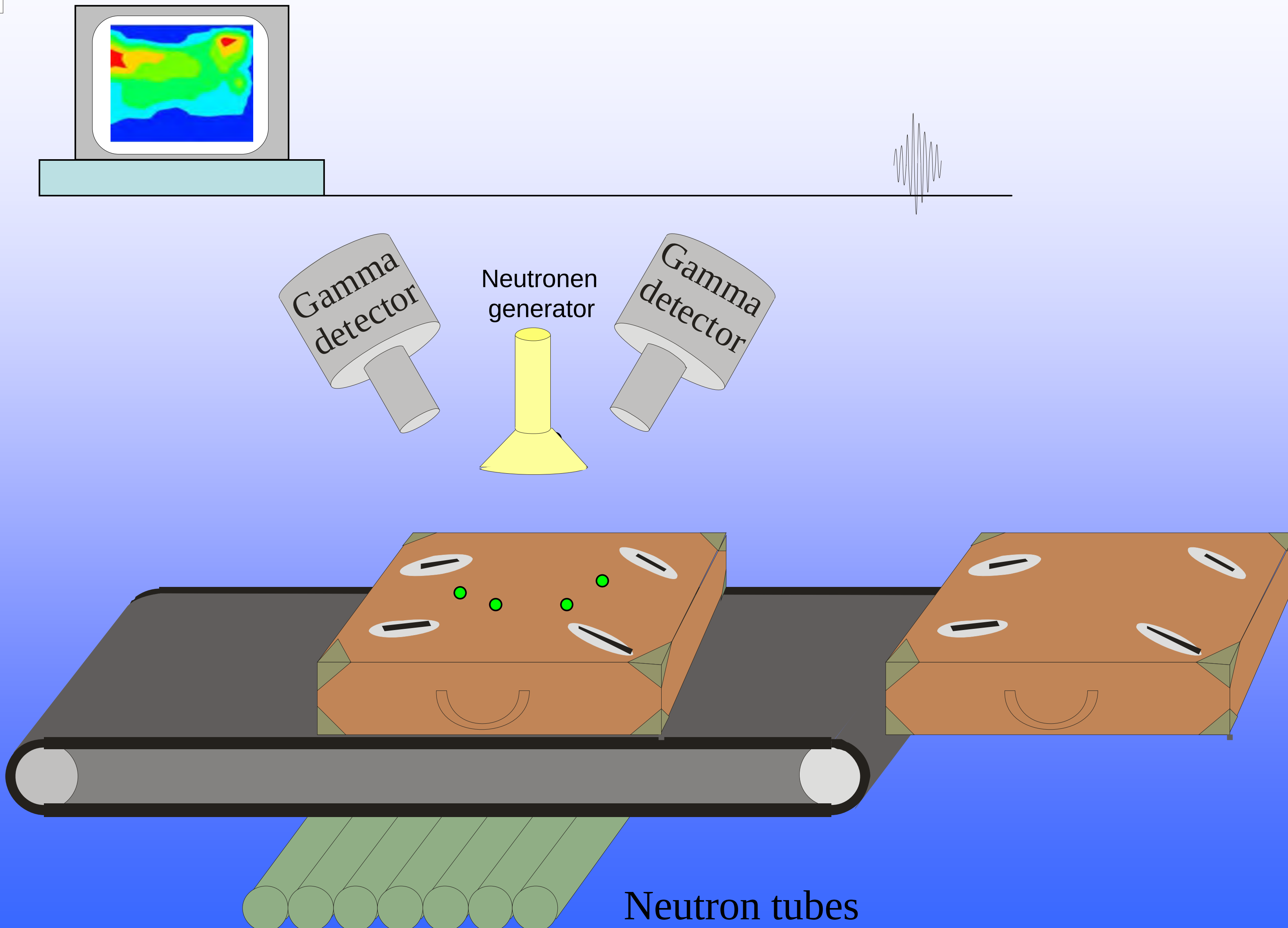
NeutroScan



Test and Evaluation (T&E) Thrust Area Overview

Eric Lowenstein, T&E Manager

Modeling & Simulation / Battlespace

October 2005

Outline

- Challenges
- Strategy
- Objectives
- T&E Focus Areas

Modeling & Simulation / Battlespace 2006 Taxonomy

M&S / Battlespace Capability Area
- CAPO
- Deputy CAPO
- Technology Transition Manager

  - CB Defense Battlespace Management
  - CB Sensor Data Fusion
  - CB Warfare Hazard Environment Prediction
  - Basic Science Program
  - CB Warfare Effects on Operations
  - CBDP M&S for Test and Evaluation
  - CBDP Decision Support Tools and Methodologies

Challenges Facing T&E Community

- Lack of state-of-the-art test equipment
- Limited methodologies
- Lack of standard procedures for T&E of CBD programs
  – Service and comm. labs and test agencies have developed mostly independent test processes. Comparison of data from individual test agencies and contractor labs is very difficult.
- No integrated approach to establishing evaluation scopes and needs
  – Program delays and cost overruns due to req. of unexpected resources and inability to establish early strategies for investment or program planning purposes.

JSTO – CBDP T&E Strategy

- Recognize the need for community involvement…
- Determine which efforts to fund and begin development of:
  - T&E technologies and capabilities
  - Specific program strategies, working closely with the Program Managers and the T&E community – at every step
  - Ultimately, standardized Joint Test Operating Procedures
- Develop overarching strategies for T&E in each commodity area…

T&E Objectives

- Implement a common set of processes for planning and executing the testing of CB defense equipment that have CB community agreement
- Enable Program Managers and evaluators to plan for a standard set of tests to evaluate equipment performance and operational impact within specified confidence limits
- Instill in evaluators the confidence that test data will be consistent from one location and one test/trial to another
- Allow the CB community to focus their limited test infrastructure resources on obtaining the appropriate test capabilities (methodologies, instrumentation, and facilities)
- Enable the user community to establish realistic criteria against which CB defense equipment can be tested and evaluated

M&S T&E Objectives

- Each commodity area requires a generic model that can be used to relate

Test data from the lab, with actual threat challenges
→ Systems trials in the field
→ Operational trials
→ Across all environmental conditions

- Ensure technical accuracy and precision
- Ensure model generates the data required to answer the question being asked

Project Selection Process

A separate T&E solicitation was necessary because the FY06 selection process had already concluded and the FY07 call would come much later.

JSTO Revised Call for Supplemental T&E Proposals

Comments to revised Call for Supplemental T&E Proposals

JSTO Call for Supplemental T&E Proposals

Phase I Submissions

Phase I Evaluation

Phase II Submission (Invitation Only)

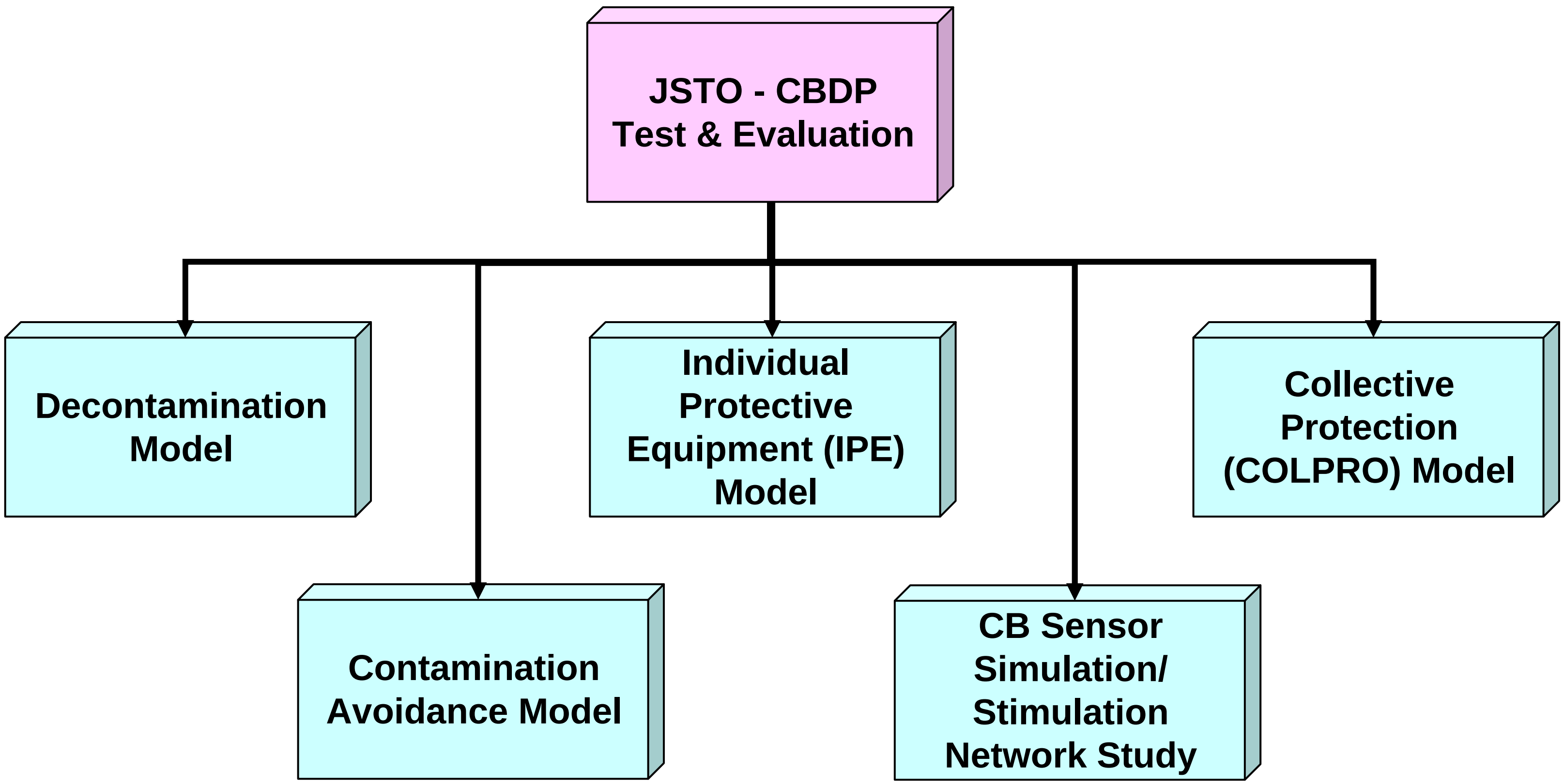
Phase II Evaluation

T&E Executive Approval

Execute

From now on, T&E needs will be addressed in the general solicitation.

JSTO - CBDP Test and Evaluation



Overarching Decontamination Model

- Addresses, contact hazards, environmental conditions, residual hazards, system degradation, and realistic threat challenges
- Enables parametric sensitivity analysis
- Performs across world-wide conditions
- Accommodates insertion of empirical data for validation
- V&V by 4Q FY08

Overarching Individual Protective Equipment (IPE) Model

- Addresses conditions to include weather, residual hazards, D-4 system degradation, realistic threat challenges, characterization of the performance envelope with respect to change over time, system load test, agent/simulant correlation, toxicity, residual life indicators
- Sensitivity analysis
- Develop analysis methods within the model to relate current test data to the toxicological endpoints (e.g. Grotte-Yang values chart)
- V&V by 4Q FY08

Overarching Collective Protection (COLPRO) Model

- Addresses weather conditions, residual hazards, system degradation, air flow and other key parameters, trade-off evaluations, realistic threat challenges, characterization of the performance envelope with respect to change over time, operational validity, system load test, toxicity, residual life indicators, novel barrier materials, new technology filtration systems and sensitivity assessment
- Develop analysis methods within the model to relate current test data to the toxicological endpoints
- Address values for challenge materials not found in existing databases
- V&V by 2Q FY08

Contamination Avoidance Model

- Integrates Contamination Avoidance capabilities into exercise detection components/systems to predict the lab-to-field performance envelope under world-wide conditions commensurate with the system operational scenarios
- Identify the critical performance areas for focusing the T&E assessment in developmental and operational tests.
- Incorporates data injects
- Includes the capability to link the newly developed T&E network environment to JFCOM exercise and experimentation environments, as well as other stakeholders (i.e., JPM-IS, Dugway, Edgewood, AFRL, NSWC, etc.)
- V&V by 4Q FY08

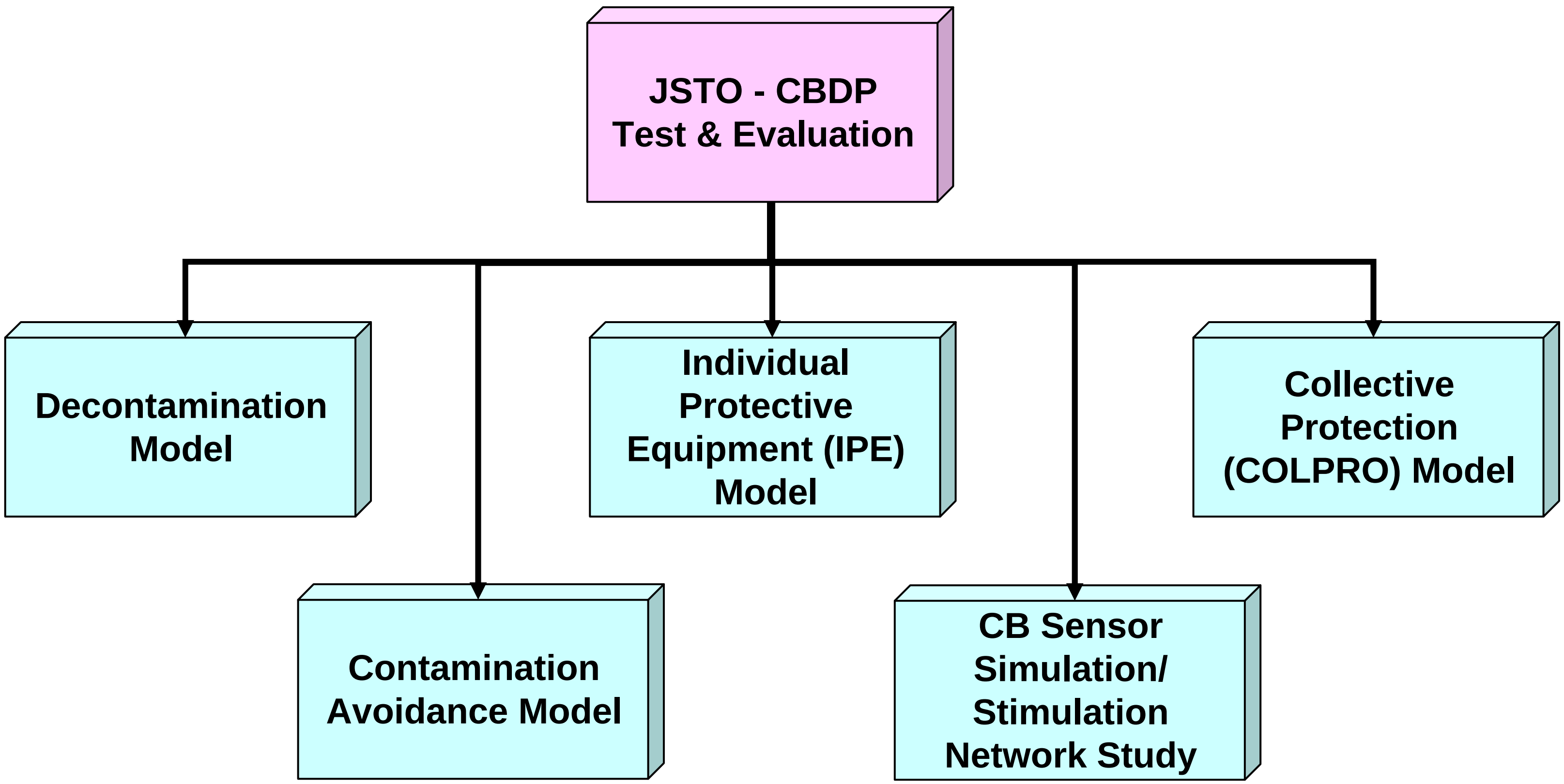
CB Sensor Simulation/ Stimulation Network Study

- Determine the requirements, interfaces, and develop a plan for building a capability for CB sensor simulators and stimulators to facilitate hardware-in-the-loop T&E in a field environment. This study will identify and characterize the planned network and tool sets, which should be linkable to other DoD labs, ranges, and selected experimentation sites (e.g., JFCOM)
- Complete by 3Q FY06

POTENTIAL FY06 Program
FY06 Program

- Community Involvement in FY06
  - Dugway Proving Grounds, Edgewood Chemical Biological Center, Lawrence Berkeley National Laboratory, Naval Surface Warfare Center Dahlgren Division, Air Force Research Laboratory, Institute of Atmospheric Sciences
  - ITT Industries; Geo-Centers, Inc.
  - UK's Defence Science and Technology Laboratory
- Active Focus Areas vs. Gap(s)

JSTO - CBDP Test and Evaluation



Summary

- Tasked to find, fund, and manage projects to develop M&S products to assist the T&E community
- Developing strategies to move forward
- Need guidance

- A DIFFICULT TASK! – WE NEED YOUR HELP!!

Questions? Suggestions?

POC:

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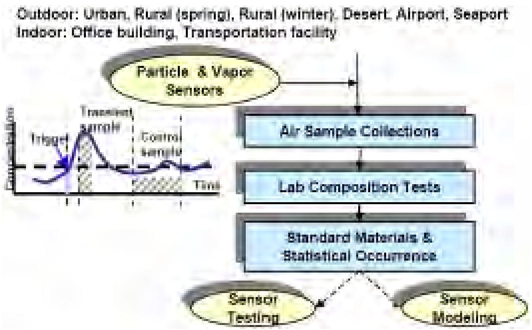
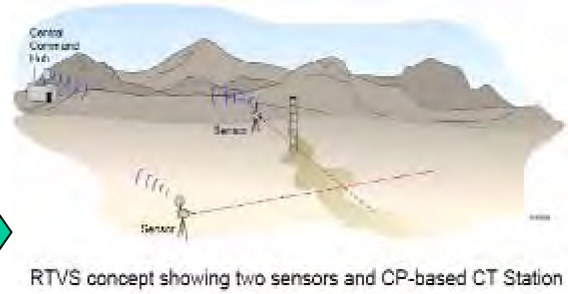
Backup

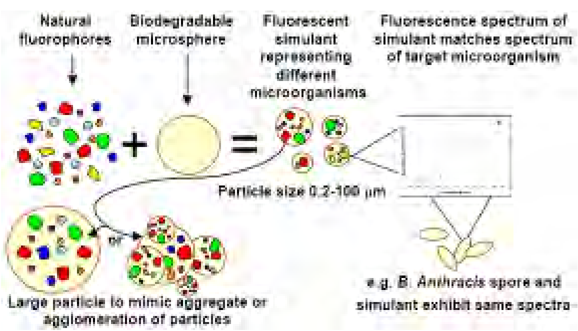
T&E technology development toward a test range capability …



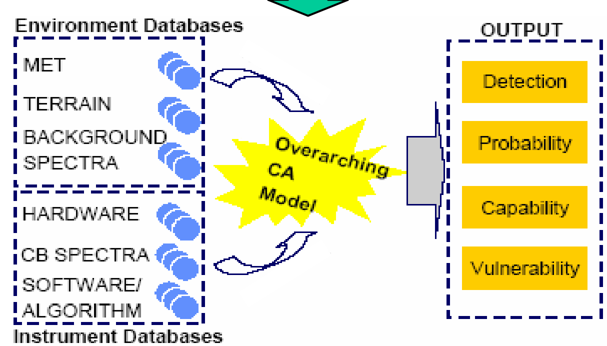
DET – Measurement of Natural Interferent Transients



DET – Range Test Validation System



TAS – Simulating Fluorescence Characteristics Using Biodegradable Microspheres



MSB - Contamination Avoidance (CA) Overarching Model

Test Range Capability

Development of simulants, test methods, and overarching models will transition to a test range capability that relates to relevant field conditions

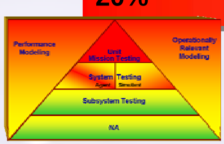
Information Systems Investment Strategy

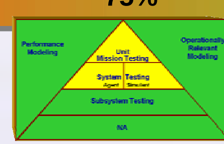
SHAPE

	FY06	FY07	FY08	FY09	FY10	FY11
CA7 (DPG)	Lab Equipment Test Facilities Improvement Support Software/IT Equipment					
	$3250K	TBD	TBD	TBD	TBD	TBD
	Control System Upgrades Lab Management Software					
6.3 JSTO	Science, Methodology and Modeling Efforts					
	$8415K	$10170K	$6095K	TBD	TBD	TBD
			Overarching CA Model Overarching IPE Model Overarching ColPro Model Overarching Decon Model			
6.4 JPEO	Advanced and System Development					
	$6000K	$6000K	$16500K	$4770K	$20000K	$1000K
	Stimulant/Stimulator Development					
	Soft and Sim/Stim Design	Hardware Build	Validate			
	Test Grid & Safari Instrumentation					
	Grid Design	Equipment Purchase	Purchase & Install	Purchase & Install	Install	Validate
Total	$17665K	$16170K+	$22595K+	$4770K+	$20000K+	$1000K+

T&E Capability

20% 30% 40% 75% 100% 100% 100%





Contamination Avoidance at Seaports of Debarkation

CASPOD

Science and Technology for Chem-Bio Information Systems

A Study in the Importance of Early User Involvement During User Interface and System Capabilities Development

Donald W. Macfarlane
David H. Drummond and William J. Ginley
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Edgewood Chemical Biological Center
Phone (410)436-5876
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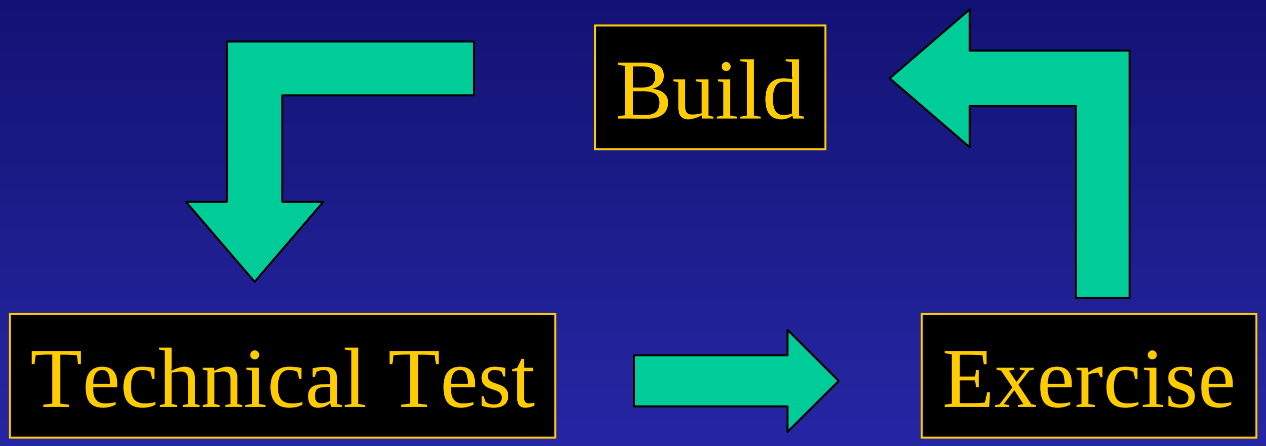
The Premise

- Every successful program must take the user needs and requirements into consideration when design alternatives are evaluated.
- Early buy in by the user and defined points for user evaluation are necessary for a successful program.
- An iterative process of build, technical test, exercise, update build, retest, and exercise is critical in providing the war-fighter a valuable system.

The Iterative Process



- Build – System is built to the basic requirements first. Follow on builds incorporate user requirements.
- Technical Test – Technical Testing completed after each build to verify functionality before being released to the user for evaluation.
- Exercise – Venue to provide operators/users with training and hands on experience in an operational scenario that is as representative of real world operations as possible.

Evolution of a System

Contamination Avoidance at Seaports of Debarkation (CASPOD) Advanced Concept Demonstration (ACTD): Information Technology Solution

Port Warning and Reporting Network (PortWARN) 2002 -2005

Science and Technology for Chem-Bio Information Systems

Science and Technology for Chem-Bio Information Systems

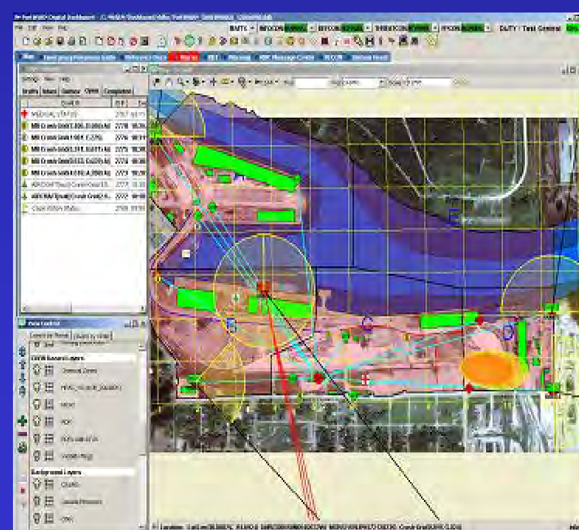
What is CASPOD?

Five Year program to address and demonstrate those mitigating actions taken before, during, and after an attack to protect against and immediately react to the consequences of the chemical or biological attack at a Seaport of Debarkation

- 3 year Technology Identification and Evaluation Phase
- 2 year Residual Support Phase
- 5 Functional Areas of Concern

Detection

Protection



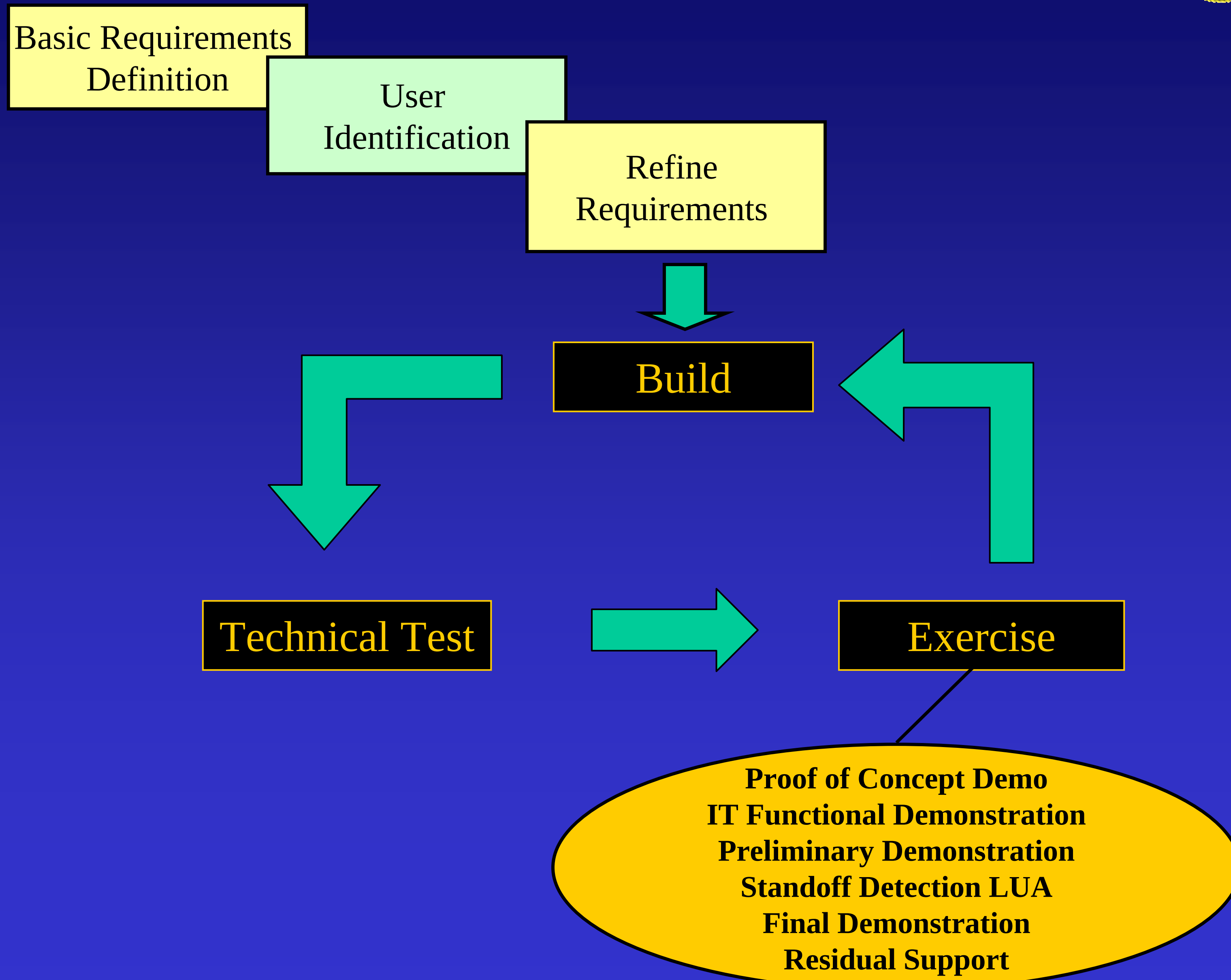
Information Technology

Decontamination

Medical

CASPOD ITERATIVE PROCESS

Science and Technology for Chem-Bio Information Systems



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CASPOD ITERATIVE PROCESS

• Basic Requirements (Management Plan)	Mar 02
• Build and test concept	Mar – Dec 02
• Proof of Concept Demonstration	Dec 02
• Refine and test	Jan – May 03
• IT Functional Demonstration	May 03
• Refine and test	May – Aug 03
• Preliminary Demonstration	Aug – Sep 03
• Refine and test	Sep 03 – May 04
• Standoff Detection LUA	May 04
• Refine and test	May – Aug 04
• Final Demonstration	Aug – Sep 04

The Beginning – Basic CASPOD IT Requirements

- Networked Detectors - Identify a networked system of detectors that can detect to warn SPOD command center, as well as USCENTCOM and USTRANSCOM Joint Operations Centers.

- Situational Awareness - Provide situational display on a common user system that gives the Commander an overall defense picture of the port , such as contamination, fires, locations of unexploded ordinance, battle damage assessment, etc.

- Audio/Visual Port Warning (Giant Voice) - Integrated alert and warning system not reliant on local power grid, providing repetitive visual and audible warning announcements to port workers.

THE ORIGINAL/BASELINE CONCEPT
Detection Network

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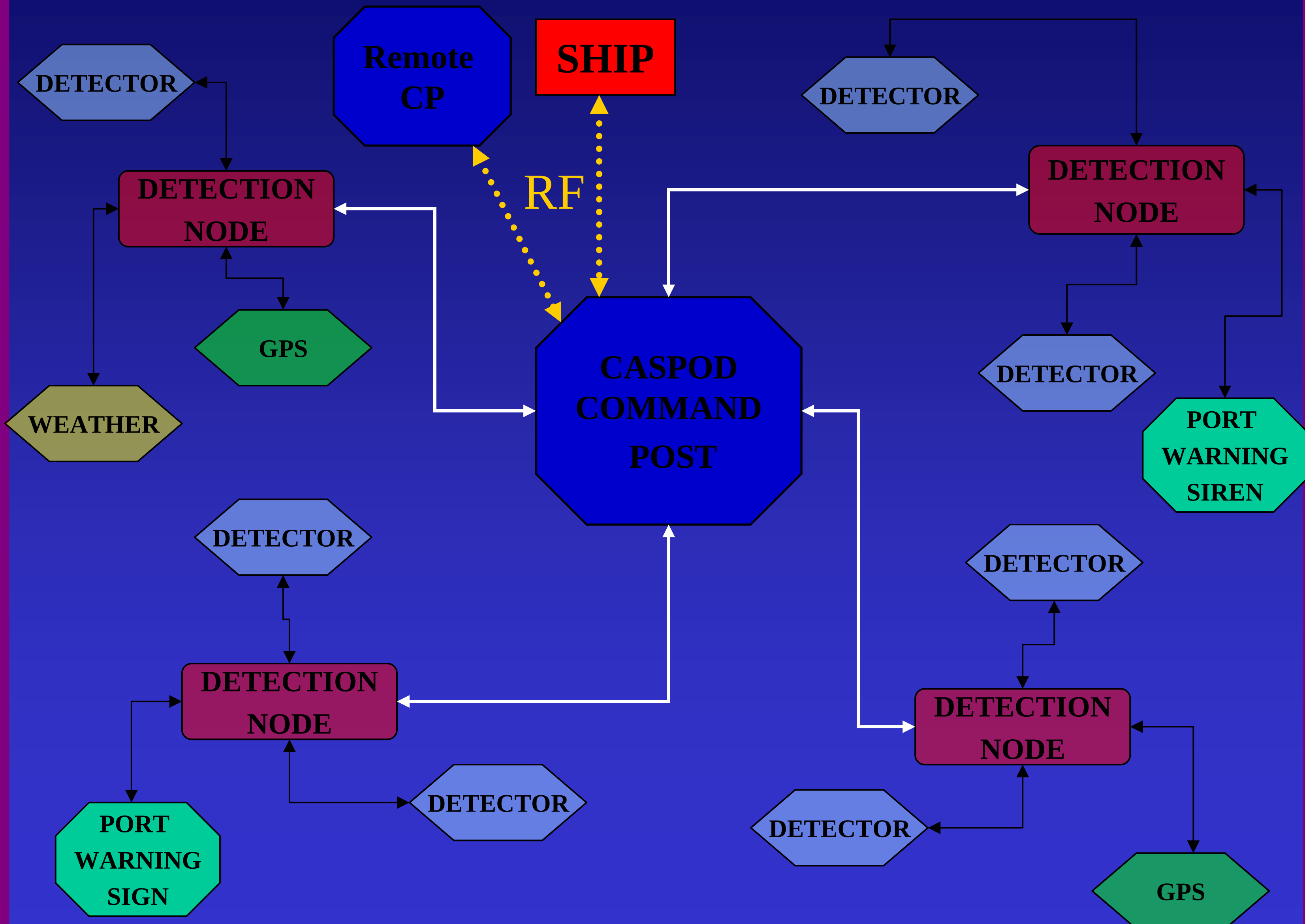

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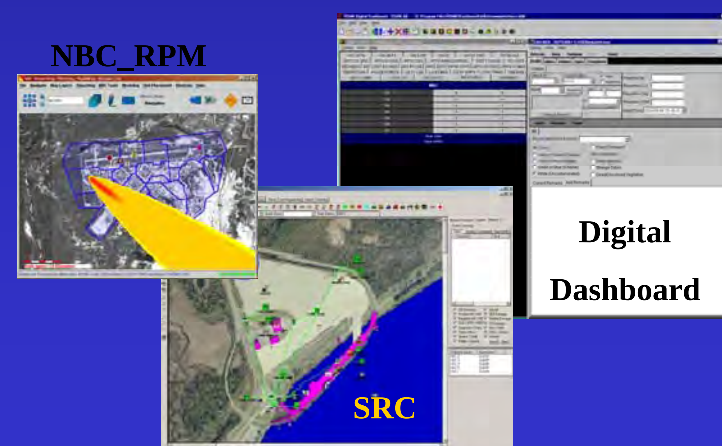
THE ORIGINAL/BASELINE CONCEPT
Situational Awareness

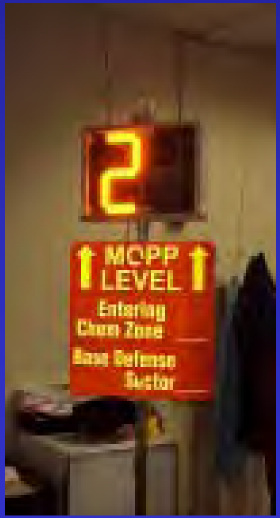
- Makes maximum use of the RestOps Information Management System
- Applicable for expeditionary force mission
- Flexible data entry
- Compatibility with multiple NBC modeling and reporting systems (NBC_RPM and JWARN)

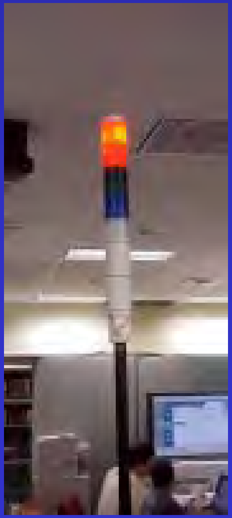
RestOps Information Mgmt System



THE ORIGINAL/BASELINE CONCEPT
Port Warning

- Port Warning System
  - Audible and visible warning
  - Connected to the network via detection nodes
  - Controlled from the command post
  - Algorithm for automated network alarm





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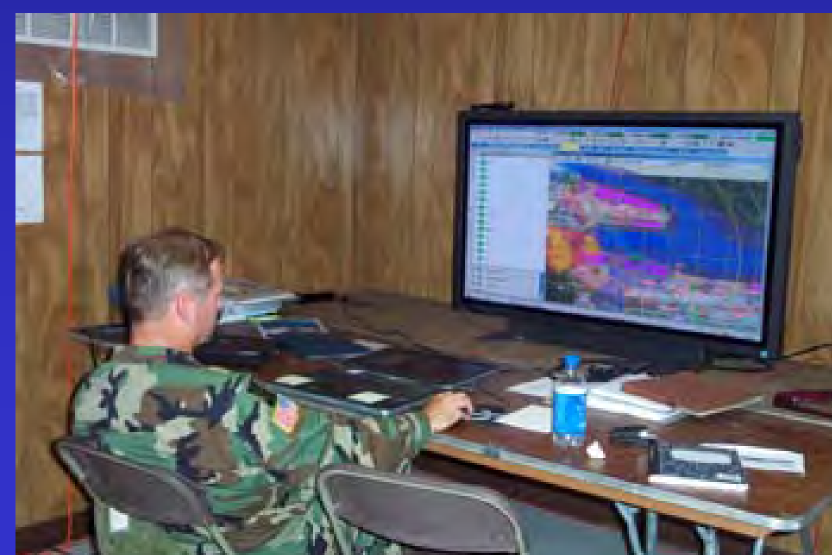
Identifying a User and Their Mission

- The Players in Port Operations
  - 143rd Transportation Command
  - 95th Chemical Company
  - 377th Theater Support Command
  - Surface Deployment and Distribution Command

- The Difficulties
  - Real world demands on the war-fighters after 9/11
  - Access to the war-fighter
  - Rotating Personnel
  - Evolving Command Structure

The Exercises



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Proof Of Concept Demonstration (Dec 2002)

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- Objectives
  - Demonstrate a network of varying sensors for detection, weather, and positioning that provided data to a central database
  - Demonstrate control of port warning from a central location
  - Demonstrate data and information flow
  - Obtain buy in for the concept from the CASPOD Management

- Capabilities
  - Situational Awareness (SRC, NBC_RPM, Digital Dashboard)
  - Detection Network (Remote Data Relay, ACADA, Met)
  - Port Warning (Concepts being explored)

- User Community Input
  - Little or no interaction with users
  - Integrate detection data with messaging
  - Improve GUI for NBC Modeling

Proof Of Concept Demonstration (Dec 2002)

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GPS, HAZMAT Sim

Building 302

Weather Station, GPS, CW Sentry Plus Sim, Solar Panels

Building 6 Tower

GPS, GID-3 Sim

RF

RF

RF

Runway CONEX

GPS, GID-3, MET-1

RF

Ethernet

BAWS, GID-3 Sim, CW Sentry SIM

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IT Functional Demonstration (May 03)

- Objectives
  - Demonstrate a network of varying sensors for detection, weather, and positioning that provided data to a central database
  - Demonstrate control of port warning from a central location
  - Demonstrate data and information flow
  - Demonstrate wireless data flow

- Participants
  - 143rd Transportation Command
  - 95th Chemical Company
  - US Army Medical Research Institute for Chemical Defense

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IT Functional Demonstration (May 03)

- Capabilities
  - Situational Awareness (SRC, Digital Dashboard & NBC_RPM)
  - Detection Network (Remote Data Relay, LCD-3, ACADA, Met, Port Warning Control)
  - Port Warning (Concepts tested, but needed refinement)

- User Community Input
  - Expand capability of NBC Modeling. Can only be run off an event.
  - Requested additional electronic attack report types.
  - Multiple recipients of Electronic Attack Reports
  - Liked the idea of merging SW tools to simplify the user interface

Port Warning Concepts

Early PortWARN Tools

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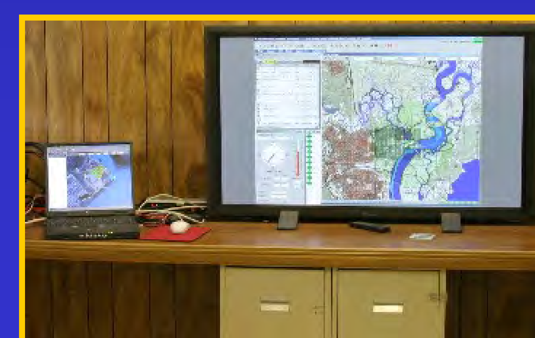
Preliminary Demonstration (Aug - Sep 03)

- Objectives
  - Demonstrate partially integrated PortWARN software
  - Demonstrate improved visual port warning concept
  - Demonstrate information flow to include NBC messaging
  - Demonstrate improved NBC Hazard Prediction user interface
  - Demonstrate audible port warning
- Participants
  - 348th Transportation Battalion
  - 95th Chemical Company
  - 807th Medical Command
  - Surface Deployment and Distribution Command (SDDC)

Preliminary Demonstration (Aug- Sep 03)

- Capabilities
  - Situational Awareness (PortWARN & NBC_RPM)
  - Detection Network (Remote Data Relay, LCD-3, ACADA, Met, Port Warning Control)
  - Port Warning (Multiple visual warning concepts and two speaker systems for audible warning)
  - NBC Messaging

- User Community Input
  - Integrate NBC Modeling with PortWARN for a simplified user interface
  - Requested additional electronic attack report types.
  - Multiple recipients of Electronic Attack Reports
  - Port Warning lights need to be brighter for daytime visibility



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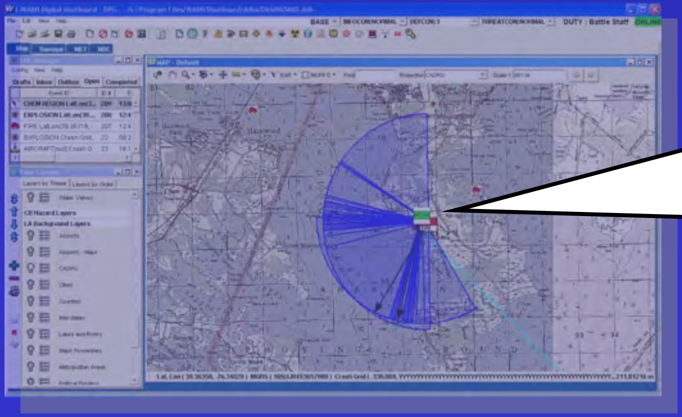
Standoff Detection LUA (May 04)

- Objectives
  - Demonstrate the suitability of standoff detection with port operations
  - Demonstrate an integrated standoff off capability controlled from a central location
  - Demonstrate data and information flow
- Participants
  - 143rd Transportation Command
  - 95th Chemical Company



PortWARN Standoff Detection Display

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Standoff Detection LUA (May 04)

- Capabilities
  - Situational Awareness (Fully Integrated PortWARN)
  - Detection Network (Standoff Detection, Remote Data Relay, LCD-3, ACADA, Met, Port Warning Control)
  - Port Warning
  - NBC Messaging
- User Community Input
  - Add multiple recipients of Electronic Attack Reports.

Final Demonstration (Aug - Sep 04)

- Objectives
  - Demonstrate fully integrated PortWARN software
  - Demonstrate improved visual port warning concept
  - Demonstrate information flow to include NBC messaging
  - Demonstrate integrated NBC Hazard Prediction
- Participants
  - 143rd Transportation Command
  - Surface Deployment and Distribution Command (SDDC)
  - 348th Transportation Battalion
  - Beaumont Fire Department

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Final Demonstration (Aug- Sep 04)

- Capabilities
  - Situational Awareness (Fully Integrated PortWARN)
  - Detection Network (Remote Data Relay, LCD-3, ACADA, Met, Port Warning Control)
  - LCD-3 Toxic Industrial Chemical Detection Added (Chlorine, Phosgene, Hydrogen Fluoride, Hydrogen Chloride, Hydrogen Sulfide)
  - Port Warning (Light Tower w/3 lights tested during FD, Omni-directional and Bi-directional speaker system integrated with PortWARN)
  - NBC Messaging

- User Community Input
  - Expand capability of NBC Modeling.
  - Add multiple recipients of Electronic Attack Reports.
  - Add warning by base defined sectors.
  - Add remote switching of LCD-3 from CW to TIC mode

Science and Technology for Chem-Bio Information Systems

Residual Support of Deployed System 2005 - 2007

- Objectives
  - Provide training to the war-fighter
  - Install fully operational PortWARN capability
  - Provide continued support through the 2 year Residual Phase
- Participants
  - 143rd Transportation Command
  - Surface Deployment & Distribution Command

Residual Support of Deployed System 2005 - 2007

- Capabilities
  - Situational Awareness (Fully Integrated PortWARN)
  - Detection Network (Remote Data Relay, LCD-3, ACADA, Met, Port Warning Control)
  - Port Warning (Light Tower w/4 lights tested during Residual Install)
  - NBC Messaging Compatible with JWARN (Demonstrated June 05 during CWID)
  - CW/TIC switching beta version in testing to be installed Feb 06
  - Port warning beta version in testing to be installed Feb 06
  - Mobile Detection Node

- User Community Input
  - Installation Sep 05 & Feb 06
  - Expand the Toxic Industrial Chemical List
  - Provide Audible Port Warning using existing port speaker system

Science and Technology for Chem-Bio Information Systems

Exercise Limitations

Challenge – Representing the Real World

- Environment
  - Exercise site limitations (i.e., Impacts on Residential Community)
  - Power (Availability, source, voltage, etc…)
  - Resources (Limited hardware and test personnel)
  - Sensor stimulation and simulation
  - Weather
- Mission – Providing representative scenarios
- User – Availability of the right user given real world mission requirements

Science and Technology for Chem-Bio Information Systems

Lessons Learned

- ***Early and constant user involvement is vital***
- ***No matter how much a system is exercised and tested, the real world will be different***
- Build systems for the real world, but also build them for training contingencies
- Don’t mix installation and training activities
  – Causes a battle for resources (people and equipment)
  – Capabilities for training may impact live system performance.

Questions?

Science and Technology for Chem-Bio Information Systems

Contamination Avoidance at Seaports of Debarkation (CASPOD) Advanced Concept Technical Demonstration (ACTD):

A Study in the Importance of Early User Involvement During User Interface and System Capabilities Development

Prepared by:

Donald W. Macfarlane
David H. Drummond
and
William J. Ginley
NBC Battlefield Management Team
Edgewood Chemical and Biological Center
Aberdeen Proving Ground, Maryland 21010-5424

ABSTRACT

The CASPOD ACTD provides a valuable example of how important the early involvement of the ultimate system user is in the development of capabilities and user interfaces. A system with suitable interfaces and adequate capabilities that meets the user's mission requirements can only be developed with a clear understanding of the user's role. The CASPOD Port Warning and Reporting Network (PortWARN) System is an example of iterative capabilities definition and iterative user interface refinement based on war-fighter inputs. The combination of war-fighter interviews, proof of concept demonstration (POCD), limited user assessments (LUA), and CASPOD Preliminary and Final Demonstrations (PD and FD) were all sources for invaluable user input for system definition.

The first step in any successful program is the understanding of the user's mission and mission requirements. Top-level requirements provide a framework for a system based on broad mission needs. By working closely with the war-fighter that will ultimately use the system, the extended detailed requirements can be defined. The CASPOD ACTD Management Plan provided the top-level requirements for a network of detectors and a situational awareness capability. Coordination with the war-fighters from the 377th Theater Support Command, 95th Chemical Company, and 143rd TRANSCOM were used to gain a better understanding of the Seaport of Debarkation (SPOD) mission and to influence the development of the detailed system requirements for PortWARN.

System definition is an iterative process that provides opportunities to get the user feedback necessary to ensure the system is of value to the war-fighter and is designed with usable interfaces. The definition of the PortWARN System was and is an iterative process. An early concept based on initial meetings with the war-fighters was presented at a POCD. Valuable feedback was gained that influenced both the capabilities of PortWARN, as well as, the user interface with the system. The feedback was used to refine PortWARN and provide a more valuable toolset for the next opportunity to gain user feedback (i.e., LUAs, PD and FD). The process will continue as PortWARN is installed and trained at the Kuwait SPOD.

Table of Contents

INTRODUCTION

Every successful program takes the needs and requirements of the user in consideration when the design alternatives are being evaluated. The best way to ensure the needs and requirements are met is to get early buy in from the user community and have defined points where the user can test and evaluate the system. In this way, feedback on system deficiencies can be provided to the developer and incorporated into the final product. An iterative process of design, technical test, user evaluation, redesign and retest is required to field a product that will provide a valuable asset and not just a memory hog that only takes up space on the hard drive.

The first step in any program is to identify the overarching requirements for a system. These are generally defined in a Mission Need Statement, Program Management Plan, and more specific requirements could be defined in an Operational Requirements Document (ORD). The lower level detail requirements are the points where specific users or user types need to be considered. In determining the final capabilities of any system, the environment in which it will be used will also be a major consideration.

The steps, procedures, and coordination trail that is required to get to that valued end product which gives the war-fighter a needed or improved capability will be described in the next pages. The focus here is on the interaction of the user with the developer and how both feed into a successful program. The developer can bring state of the art concepts and innovative technology to meeting the war-fighters needs, while the war-fighter brings the reality of mission needs and the mission environment.

The Contamination Avoidance at Seaports of Debarkation (CASPOD) Advanced Concept Technology Demonstration (ACTD) is a prime example of how the developer and the war-fighter can come together to influence system requirements and capabilities. The CASPOD ACTD followed, and is still following the iterative process to link new and emerging technology with real world mission requirements. The focus of the following discussion is on the information technology (IT) and detection network requirements for the CASPOD ACTD.

WHAT IS CASPOD?

The CASPOD ACTD is a 5-year program to address and demonstrate those mitigating actions taken before, during, and after an attack to protect against and immediately react to the consequences of the chemical or biological (CB) attack at a Seaport of Debarkation (SPOD). These actions aim to restore operating tempo in mission execution and the movement of individuals and materiel through a SPOD to support combat operations. The ACTD addresses both technology solutions and doctrinal solutions in order to mitigate the effects of a CB Warfare Agent attack or a

release of Toxic Industrial Chemicals (TIC) on force flow and operational tempo within a SPOD.

The Edgewood Chemical and Biological Center (ECBC) has been tasked as the Technology Integrated Process Team (IPT) for the CASPOD ACTD. The IPT has been tasked with identifying existing and emerging technologies with applicability to CASPOD in the functional areas of Detection, Decontamination, Protection, Medical and Information Technology (IT). The initial 3 years of the ACTD focused on the identification and evaluation of applicable technologies in each of the functional areas and the final 2 years are focused on residual support and transition of the downselected technologies. The CASPOD ACTD has completed the evaluation phase of the program and is now in the final 2 year Residual Support Phase.

The focus of the discussion on the user/developer interaction provided in the following pages is directed at the IT Solution that was implemented for the CASPOD ACTD in the form of the Port Warning and Reporting Network (PortWARN). The discussion is however, just as relevant to the other functional areas.

THE BEGINNING – BASIC REQUIREMENTS

The mission capability or more accurately the lack of a mission capability is the starting point for defining requirements for any program. The CASPOD Management Plan provides the basic requirements for IT capabilities. The basic requirements are broken out into 4 requirements.

1. Network of Detectors. Identify a networked system of detectors that can detect to warn SPOD command center, as well as, USCENTCOM and USTRANSCOM Joint Operations Centers.

2. Situational Awareness. Provide situational display on a common user system that gives the Commander an overall defense picture of the port, such as contamination, fires, locations of unexploded ordinance, battle damage assessment, etc…

3. Port Warning. Provide integrated alert and warning system not reliant on local power grid, providing repetitive visual and audible warning announcements to port workers.

4. CENTRIXS Compatibility. Network software/operating system must be compatible/interoperable with current and the projected Combined Enterprise Regional Information Exchange System (CENTRIXS) C2/Information system.

These basic requirements are top level with no direction on how to implement them in a field-able system. This is where the developer/integrator and the user need to begin a collaborative effort and define the specifics for the system. In the case of

CASPOD this was easier said than done. The real world events following 9/11 made the availability of and access to the user community very limited. Developing the concept and adding some specifics to the requirements in the initial days of the program had to rely on limited interaction with the user community and on the past experience of the developers. Drawing on the experience the Tech IPT had with the Restoration of Operations (RestOps) ACTD; the team evaluated available technologies and developed a concept for what would ultimately become the Port Warning and Reporting Network.

THE ORIGINAL/ BASELINE CONCEPT

The original or baseline concept was for an integrated solution to meet the four top-level requirements since no single system or tool met all the requirements. The CASPOD Information Technology Working Group (ITWG) worked towards a solution that would integrate the network of detectors with port warning, NBC modeling, and NBC reporting all controlled from a central command post. The concept that emerged was to have detection nodes that could have four or more different sensors connected at each node. The configuration of each node could vary to provide the maximum coverage possible. Each detection node would be connected to the central command post via radio or Ethernet. Each detection node would be capable of connecting to a port-warning module and providing the path for controlling the port warning from the command post. The Remote Data Relay from Sentel was selected for use as the backbone of communications between the detection nodes and the central database.

Figure 1 – Remote Data Relay (RDR)

The sensors to be integrated in the network would be a combination of currently fielded chemical and biological warfare agent detectors, toxic industrial chemical, weather sensors, and global positioning systems. The ITWG worked closely with the Detection working group to identify the detectors to be integrated into the network and to obtain the detector interface control documents. The CASPOD IT Network Schematic is depicted in figure 2.

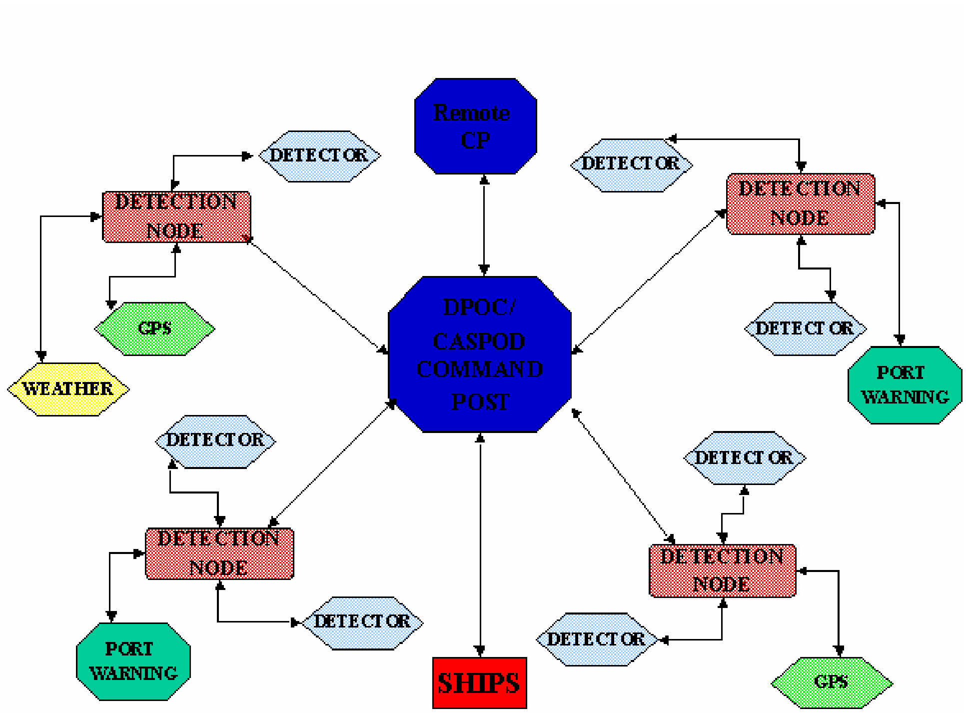

Figure 2 – CASPOD Detection Network Concept

The Restoration of Operations (RestOps) ACTD provided the basis for the situational awareness capability in the form of the RestOps Information Management (ROIM) System. The ROIM System would be used to the maximum extent possible per the CASPOD Management Plan. The ROIM tools provided the situational awareness mapping, NBC messaging, hazard prediction and hazard plotting. The sweep tool component of ROIM provided a quick and easy method for inputting sweep results. As the concept of operations (CONOPS) was further defined, the locations and number of workstations were to be determined. As a minimum, the Command Post would also serve as a workstation. The ROIM tools had significant and successful testing during two Functional Tests conducted at the Air Force Research Laboratory (AFRL) and during the Combat Effectiveness Readiness Exercises (CERE) at Osan Air Force Base in FY02.

Figure 3 – RestOps Information Management System in use at Osan AFB

The port warning system provides a visible and audible warning using commercial off the shelf technology. Several vendors were identified and the selection of the final configuration was made based on factors such as ease of use, network compatibility, power, size, cost, etc… The port warning system selected would have an interface with the network to allow the quickest possible warning to the port workers.

The Remote Data Relay (RDR) is a Sentel Corporation product that provided connectivity of disparate sensors, remotely located sensors and other electronic devices into a single, integrated network. The output of each sensor can be monitored from the CASPOD command post. Each RDR can connect up to 8 serial devices and 3 digital control devices. Each RDR can be connected to the command post via radio or Ethernet.

This original or baseline concept was ready to test and the time had come when user input was desperately needed to identify the shortcomings from an operational point of view. The system was briefed to the potential users of the CASPOD technologies. The first in a series of limited user assessments and demonstrations was scheduled. These assessments and demonstrations provided the mechanism for gaining user feedback, but first the users had to be identified.

IDENTIFYING A USER AND THEIR MISSION

The time had come to get the user involved and in the case of CASPOD we sought the help of the 95th Chemical Company, 143rd Transportation Command

(TRANSCOM), Surface Deployment and Distribution Command (SDDC), and 377th Theatre Support Command (TSC). These are the units identified by the Operational Manager (OM) and the sponsoring command, Central Command (CENTCOM) as the main elements for maintaining port operations. The question that was still to be answered was who would the ultimate user of the system be? That question is still being defined today.

Once the potential users have been defined, the next step is to understand the mission of those users. To understand the mission of the users, time needs to be spent with the men and women learning and understanding their roles and responsibilities. This proved more difficult in CASPOD than in RestOps. With RestOps we had a well established user with defined timelines for quarterly CERE that provided ready access to observe operations. CASPOD came along at a time when real world operations made access to the units limited and much more difficult.

We were able to visit the 377th TSC in April of 2002 and the 95th Chemical Company in July of 2003. These trips along with visits to the 143rd TRANSCOM Headquarters in Orlando, FL and to SDDC headquarters at Ft, Eustis in Virginia began to lay the groundwork for developing the concept for the CASPOD IT solution, Port Warning and Reporting Network (PortWARN). These visits were very good in providing a rudimentary understanding of port operations and made clear the main mission of the 143rd and SDDC is moving cargo to support our troops. The problem arises when we realized a rudimentary understanding is not enough and a more advanced understanding is required to provide a system that can meet the needs of the user.

The rudimentary education we received provided an understanding of the functions and the organizations that are necessary in moving materiel through the port and onward to the operational units. The missing piece was a clearly defined command structure and a clearly defined set of responsibilities for each organization. The standard operating procedures (SOPs) for port contingency operations were still evolving and will continue to evolve as the CASPOD technologies are rolled in. As we moved into the demonstrations of the CASPOD IT solution, the command structure was a moving target and was defined based on current doctrine for each event.

The demonstrations and limited user assessments were the beginning of the iterative process. The series of technical and operational demonstrations were geared towards evaluating PortWARN and gaining insight into the operator's real world responsibilities.

OPPORTUNITIES FOR USER INPUTS

The CASPOD ACTD built in opportunities for the user community to provide the real world perspective and real world mission experience to the developers and

integrators of PortWARN. From early technical demonstrations through deployment of hardware and software, the war-fighters that would be the operators of PortWARN were made available to evaluate the system. In some cases the PortWARN operator used during an event was not likely to encounter PortWARN in his future duty position, but that operator's input was still valuable with regard to the basic user interfaces. In other cases, the players in the Final Demonstration were the ultimate user of the deployed PortWARN system. These operator's comments were doubly important because they addressed the user interface, but more importantly their comments impacted on the performance of their mission and the impact PortWARN had in performing that mission.

The events that took place provided the venues for the iterative approach of design, test, evaluate, redesign, retest, re-evaluate, etc… The events ranged from a Proof of Concept Demonstration through training with a tabletop exercise with the gaining unit as part of Residual Support. The types of events were designed as technical demonstrations follow by operational events to evaluate the military utility of the PortWARN System. Each event provided valuable insight into the user's real world needs, real world force structure, and real world mission as briefly described below.

Proof of Concept Demonstration: A Proof of Concept Demonstration (POCD) is exactly what it sounds like, a chance to demonstrate the CASPOD IT solution capabilities, graphical user interface, and information flow. In the case of the POCD, the demonstration was for the CASPOD Operational Manager, Technical Manager, Military Utility Assessor, and interested parties from the sponsoring command, CENTCOM. The POCD was held at the Air Force Research Laboratory (AFRL) in December of 2002. Training was provided to participants and a limited amount of tabletop exercise play was conducted. This was the first opportunity for the CASPOD Management to see and operate the initial tool set being proposed by the ITWG.

Objectives: There were several objectives to the POCD, both technical and non-technical. The technical objectives included demonstrating: (1) a network of varying sensors for detection, weather, and positioning that provided data to a central database; (2) control of port warning from a central location; and (3) demonstrating data/information. The main non-technical objective was to get buy in to the proposed solution from the CASPOD Management.

Setup: The setup consisted of five detection nodes spread out across the rooftops of AFRL in Rome, New York. The detection nodes were populated with a mix of live sensors and simulated sensors. A command post was simulated in the office space at the lab and several remote clients were set up in adjacent areas of the lab. Port warning and an interface with CENTRIXS were not demonstrated at the POCD. Concepts were briefed but the cost and technical data was still being collected in December of 2002. A wireless capability was setup that demonstrated the ability for the situational awareness data to be transmitted at high speed to make the addition of

remote clients a viable option. The wireless capability was not a stated requirement but would come in handy during the Preliminary Demonstration in Aug-Sep 2003.

The software tools demonstrated were the RestOps Information Management (ROIM) System consisting of the SRC 3.0 Map application, digital dashboard sweep tool, and Nuclear Biological Chemical_ Reporting, Plotting and Messaging (NBC_RPM).

Figure 4 – Proof of Concept Demonstration

Limitations: The POCD demonstrated a limit amount of the capability that would eventually be added to PortWARN. The primary focus of the demonstration was on the display of data and ability to provide sensor data in near real-time to the common operating picture.

Information Technology Functional Demonstration: The Information Technology Functional Demonstration was held in of May 2003. The demonstration was conducted at AFRL in Rome, NY and was the first opportunity for members of the 95th Chemical Company and the 143rd TRANSCOM to operate the PortWARN system. The 95th Chemical Company played the role of NBC Officer and the 143rd provided the players for the Port Commander and the Port Manager. Contractors with previous military experience filled the roles of the other staff positions.

Objectives: The objectives of the Information Technology Demonstration were to demonstrate: (1) a network of varying sensors to include detection, weather, and global positioning systems; (2) information flow to a central database; (3) concepts for port warning controlled from a central location; and (4) wireless data transfer. Additionally, the non-technical objective for the demonstration was to spend time with the 143rd and 95th to gain as much information and insight as possible on port operations, decontamination operations, mission responsibilities, command structure, and existing communications and information exchange processes.

Setup: The setup consisted of six detection nodes spread out across the rooftops of AFRL. Each detection node consisted of an RDR and one or more sensors. One node was setup to hand the audible warning using either an omni-directional speaker or a set of bidirectional speakers. Both live sensors and simulated sensors were used to inject data into the system. Live detection sensors were alarmed using confidence tester simulants. The software demonstrated was again the ROIM tools with a few minor additions to give the application more of a port flavor. For hazard modeling, VLSTRACK was replaced by the Hazard Prediction and Assessment Capability (HPAC) to provide a simpler user interface.

The overall system at this point in time was dubbed the CASPOD Battle Management System (CBMS). CBMS would be a short lived name and was morphed into the Port Warning and Reporting Network (PortWARN) by the end of 2003.

Limitations: The Information Technology Demonstration provided a demonstration of the core technologies and some of the concepts that were still being evaluated for PortWARN. The major limitations to the demonstration were both technical as well as operational. The technical limitations included system power, detector availability, and simulation development.

Power was readily available for the detection nodes, but this is not representative of the operational environment. One challenge that was faced later in the ACTD is the design of power supply system for the deployed detection nodes. During the early stages of the ACTD the detection devices being used were generally on loan from vendors or other Government organizations and final selection of detectors was not completed. Until the selection of the detectors to be used by CASPOD was finalized, only limited work would be done on integration of the detectors. The simulation for standoff detection was developed quickly and was labor intensive to create each individual scenario.

The demonstration setting was non-operational and limited training time was available. In order to promote the use of the system to demonstrate its capabilities, the technical team was asked to operate the main screen for the commander. The authors of the mission event scenario list (MESL) for the demonstration had limited experience with regard to port operations and the MESL did not necessarily reflect the port operations very well.

***Preliminary Demonstration*:** The Preliminary Demonstration (PD) was held at the Naval Weapons Station in Charleston, SC in August and September 2003. This was the first of two operational demonstrations used to provide military utility assessment data for the evaluation and final down selection of technologies. The PD addressed all five functional areas of the CASPOD ACTD, but again the focus for this discussion is the IT solution, PortWARN. The participants included the 348th Transportation Battalion, 95th Chemical Company, 807th Medical Company, and SDDC.

Objectives: The main objective of the PD was of course to demonstrate the military utility of the PortWARN system. More specifically, the objectives were for the Tech IPT to demonstrate: (1) integrated PortWARN software; (2) improved visual port warning concept; (3) information flow to include NBC messaging; (4) improve NBC hazard prediction interface; and (5) audible port warning.

Setup: The setup included 10 PortWARN Clients online with the map situational awareness GIS application integrated with the digital dashboard. The NBC_RPM was still a stand alone application tied to the common database. Eight (8) detection nodes were setup in various configurations. The sensors that were integrated into the detection nodes included the LCD-3, BAE JCAD, M22 ACADA, Mobile Chemical Agent Detector (MCAD), GPS, and weather. Audible port warning was integrated into PortWARN and was controlled from the Combined Port Operations Center (CPOC). Visual port warning was provided in the CPOC using a small stackable light and outside using a traffic light configuration. The visual warning was also integrated with and controlled through the PortWARN software. A wireless feed was provided so a client could be placed in the White Cell (Test Control) trailer.

Limitations: The Port Operations Concept of Operation were still being defined at the time of the PD and the participants struggled with incorporating their past experience with the current technology. After Action Reviews (AARs) proved helpful in exploring the capability of PortWARN and how the tools could be employed throughout the MSEL play. Again, the scenarios were limited in scope given the relatively small window of time that the MSELs were played. Some of the technical limitations included the elevation of the speakers and the need to simulate the standoff detection.

Standoff Detection Limited User Assessment: A Standoff Detection LUA was held in May 2004 to address the potential of providing and integrating a standoff chemical detection capability as a residual for CASPOD. The 95th and the 143rd again supported the LUA and played the roles of NBC Cell and Port Commander. The Standoff Detection LUA took place at Dugway Proving Ground, Utah.

Objectives: The objectives of the Standoff Detection LUA were to demonstrate: (1) the suitability of standoff detection with port operations; (2) an integrated standoff detection capability controlled from a central location; and (3) the ability of PortWARN to display standoff detection data in a meaningful way.

Setup: The setup consisted of 10 PortWARN clients online with the fully integrated PortWARN software. Fully integrated in this case means a single application providing the user interface for geo-referenced situational awareness, sweep capability, NBC hazard prediction and modeling, port warning control, standoff detection control, etc… Two MCADs connected to RDRs were used as a

representative system for standoff detection. Meteorological data was provided by a met sensors connected to a RDR.

Limitations: The LUA was conducted in a non-operational setting, Dugway and the participants from the 95th Chemical Company were members of a decontamination unit and unlikely to be users of the system in a real world contingency. Simulant releases were limited to a defined area, making it necessary for the detection units to be moved in order to test a various ranges. The units were mounted in Cherry pickers and lowered for transport. Leveling of the detector was done on the ground before elevating it to the operational height. Alignment of the unit could not be maintained using this procedure and could have influenced the results.

Final Demonstration**:** The Final Demonstration (FD) was held at the Port of Beaumont, in Beaumont, TX in August and Sep 2004. The Port of Beaumont is reportedly the busiest military port within the United States. The 143rd TRANSCOM, SDDC, 348th Transportation Battalion, and the Beaumont Fire Department were the participants for the FD.

Objectives: The objectives for the FD were to demonstrate: (1) a fully integrated PortWARN software; (2) improved visual port warning; (3) information flow to include NBC messaging; and (4) integrated hazard prediction.

Setup: The setup consisted of 14 PortWARN clients online loaded with the fully integrated PortWARN software. Six detection nodes were erected with a mix of LCD-3 and M22 ACADA detection systems. Five sites were equipped with port warning light towers and two had speakers systems attached. The omni-directional speakers were ground mounted near the pier and the bidirectional speakers were mounted on a cherry picker for elevation. The unique feature of the setup was there were 7 additional detection nodes simulated and displayed on the PortWARN map.

Limitations: The limitations included: (1) the limited equipment and manpower made it necessary to simulate entire detection nodes; (2) simulant could not be release making it necessary to simulate the standoff detection; (3) speaker was limited due to the proximity to a neighborhood church; and (4) the event scenario was limited in time and scope – no night operations. The FD was the most realistic setting of all the demonstrations and LUAs conducted, but volume of cargo and the volume of people of a real world operation could not be replicated.

RESIDUAL SUPPORT**:** Installation of the PortWARN in an operational port took place in September 2005. The residual support in the case of CASPOD may be the most informative of all the user/developer interactions. A thirty-day visit to the unit gaining the system can be more valuable than all the previous trips and meetings combined. Spending those days on site with the 143rd TRANSCOM and SDDC gained the development team an insight into the real world operations in a port and the expectations of the real world events that impact a port.

Objectives: The objectives of the Tech IPT were: (1) to install the full operating capability of PortWARN with the exception of the audible warning; (2) to provide PortWARN operator training; (3) to validate performance of the deployed network; and to support a table top exercise with the PortWARN operators.

Setup: There were 10 fixed site detection nodes and 3 mobile detection nodes mounted in trailers installed. Each detection node consists of the RDR, LCD-3, light tower; and battery solar panel power assembly. Four PortWARN clients are online with one driving a 50" display.

Limitations: The limitations for the efforts during installation and training included: (1) equipment resources were limited and required dual use as training assets and live system testing assets; (2) early training scenarios were unrealistic; (3) training done offline from the operational network in a classroom setting; and (4) all detections were simulated.

EVOLUTION OF A SYSTEM

The list of technical demonstrations, user assessments, and operational demonstrations is quite impressive for the PortWARN system. Each one of those events provided valuable information from the war-fighter, the port commander, and even from the occasional misplaced person that will be unlikely ever to operate PortWARN again. If you track the changes in the setups for each of the events discussed in the previous pages, you can see the evolution of the PortWARN system from a concept created by the joint experience of a handful of developers to a deployed system with the mark of many users. At the end of each of the events, many comments were received and when technically feasible and where a reoccurring theme was identified, improvements were incorporated into PortWARN.

In 2002, the concept that was called the CASPOD Battle Management System had capabilities with respect to the situational awareness and detection network requirements that were mandated in the CASPOD Management Plan. Three separate software tools provided the capabilities for situational awareness: Survival Recovery Center 3.0, Digital Dashboard, and NBC Reporting, Plotting and Modeling (NBC_RPM). These applications ran independently with different user interfaces, but shared data by feeding a common database. Development of a common user interface was desired to make the training and operation of PortWARN more user friendly. NBC hazard prediction, NBC messaging, and integration of the detection data into the modeling and messaging were other areas that were identified for further refinement. In 2002, the port warning concepts were just beginning to be explored and CENTRIXS was identified as a capability to address later.

The year 2003 brought significant user input, added capability and a new name, PortWARN. The IT Functional test and the PD provided two significant opportunities for the users to have hands on experience with PortWARN and give the

Tech IPT some valuable feedback and insight into port operations and mission requirements. The SRC3 capabilities were integrated into the digital dashboard and HPAC was integrated with NBC_RPM providing simplified user interfaces. Audible and visual port warning was demonstrated, but not finalized as issues like the brightness of the lights and loudness of the speakers were identified. Detection integration with the RDRs was on going for several detectors being evaluated under CASPOD.

In 2004, the Standoff Detection LUA and the FD again brought the user community in direct contact with the developers for a valuable exchange of information. PortWARN was fully integrated with a three components now under the umbrella of the digital dashboard. A TIC detection capability for a limited number of industrial chemicals was added to the LCD-3. A light tower with red, yellow, and green lights was designed, built and tested and received favorable reviews from the participants of the FD. A CENTRIXS Solution was designed and coordinated with the CENTRIX Program Office.

In 2005, a single PortWARN detection node was deployed for environmental testing. A solar panel battery power assembly was designed and built to minimize the logistics burden of powering the PortWARN nodes. The LCD-3 TIC library was expanded to include sulfur dioxide. The PortWARN message center was demonstrated to be compatible with the program of record, JWARN (Joint Reporting and Reporting Network). The PortWARN system was deployed and training provided to the gaining unit. Continued support will be provided throughout 2006 and into 2007 as part of the CASPOD Residual Support Phase of the program. Throughout the Residual Phase, reliability, availability, and maintainability data will collected and refinements and improvements will be added as appropriate to minimize the logistics burden on the unit.

LESSONS LEARNED

Many valuable lessons have been learned throughout the CASPOD ACTD. First and foremost is that user involvement early and often is essential in building a system that has value to the war-fighter. Understanding the mission of the war-fighter that will be using a system early in the development process helps the developer avoid the pitfalls born out of inexperience. Understanding the mission and the deployed environment will help drive the detailed requirements of a system, help generate a more valuable training package, and ensure the system is of value in the field.

No matter how much a system is exercised and tested, the next environment will be different. The environment in this case means a wide range of things that include everything from a physical feature of the location to just the number of detection nodes that are required. In every case the environment for the demonstration and deployment has caused some kind of issue. For example, the PD required the use of the wireless connection and this had been technically tested at the POCD and worked

well. Unfortunately, at the PD a line of trees was in the path and added elevation was required. No usable towers were available, so a few quick phone calls were made and two telescoping masts were acquired to add height to the wireless antenna.

Prior to the FD demo the number of users had never exceeded 10 at one time on PortWARN. That number was exceeded and the combination of a large volume of users and a memory leak with the software that wasn't evident during technical testing brought the system to a crawl after a few hours of operation. Some long hours and hard work solved the problem and the FD was completed successfully. The deployment brought several challenges as well, from how to power the detection nodes to how to handle the simulation for training. Power was not readily available and the logistic burden of filling and maintaining generators was unacceptable, so a solar/battery power assembly was design and successfully deployed.

These were just a few examples of how an unknown issue that was not anticipated can cause reworks or the development of creative solutions. The goal is to minimize and anticipate the major hazards, so the minor ones can be handled. One factor that may not ever be able to be anticipated is the human element. The users are not developers and developers are not the users. The developer tends to test in a methodical way and in the same pattern. Unfortunately, real world events and war-fighters in the field tend to do things in a random way. The developer can't foresee all the potential random combinations that could happen and cause problems within a software system. During training for the deployed system one operator opened a minimum of six maps at once and up to 15. Testing had been done with two and possibly three maps opened with no problem. The maps are fairly memory intensive and the additional maps caused the client to lock up. The developers never saw the need for more than a few maps opened at the same time and didn't think to open six let alone 15 maps at once. The main point here is the developer can't replicate every combination of actions in the lab that will be taken in the field.

Training will always be an issue with any fielded system and two points need to be made with that in mind. First, definitely make use of subject matter experts to ensure the training is representative of the unit's mission and the real world threat at the time. Unless the training can be related to the mission and the threat it will be of limited value when a system is called into service for a real world contingency. Secondly, to the maximum extent possible keep installation and training activities separate. This maybe possible either by schedule or by increased resources, but when these activities coincide there is a battle for resources in both equipment and manpower.

In closing, the emphasis is and always should be on the war-fighters and their needs and requirements. Early involvement is essential and can impact favorably every aspect of a system from the system functionality through the system logistical tail. Training is a vital part of any system package and the early understanding of the unit's mission can go a long way in building a training package that provides a

representative scenario that prepares the user for real world operations. Again get the user involved early and often.

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Infrared Scene Simulation for Chemical Standoff Detection System Evaluation

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Why Synthetic Scene Simulation?

- Evaluation of New System/Sensor Designs and Concepts
- Evaluation of New Data Exploitation Algorithms
- Evaluation of New ConOps for Existing Systems

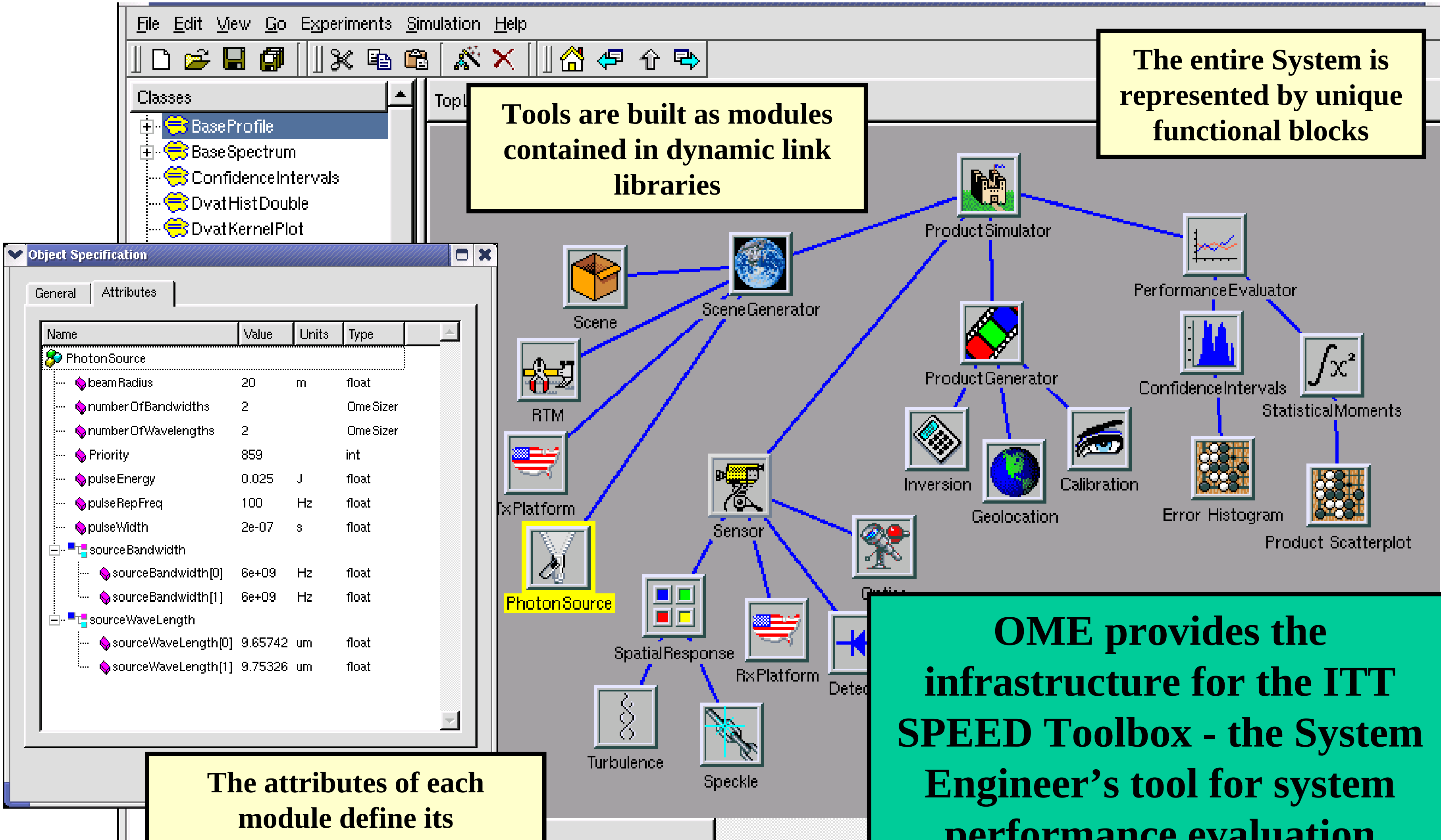
Issues Regarding Scene Simulation

- Background Clutter
  - Do simulated spatial distributions match reality?
  - Is simulated spectral variation realistic?
- Target Insertion
  - Are target absorption properties correct?
  - Insertion techniques
  - Interaction with other naturally occurring gases
- Horizontal Radiative Transfer
  - Problem using MODTRAN to calculate the atmospheric transmission for horizontal and near horizontal geometries
    - MODTRAN horizontal mode assumes constant pressure, therefore slant path mode must be used.
    - Large ranges resulting from a line of sight nearly tangential to the earth's surface caused MODTRAN to fail on computing the layer thicknesses required for the transmission calculations.

Scene Simulation Plan for Sensor Evaluation

- Scenarios
  - Downlooking Scene Using Simulated Backgrounds
  - Horizontal Scene Using Simulated Backgrounds
  - Downlooking Scene Using Measured Backgrounds
- Scene Specifications
  - Pixel size: 1 m
  - Image size: (1000 - 2000 m) x (4000 - 5000 m)
  - Spectral resolution: 2 cm^{-1}
  - Wavelength range = 700 - 1400 cm^{-1}
  - Radiance units = W/cm^2 sr cm^{-1} or uW/cm^2 sr cm^{-1}
  - Cloud size = 30 m height, 300 m width, 100 m length
  - Cloud concentration lengths: 0 - 1000 mg/m^2
  - Vapor target: GB
  - Mean ΔT: 5K

The SPEED Toolbox Provides the Foundation for Scene Simulation



Tools are built as modules contained in dynamic link libraries

The entire System is represented by unique functional blocks

The attributes of each module define its characteristics.

OME provides the infrastructure for the ITT SPEED Toolbox - the System Engineer's tool for system performance evaluation

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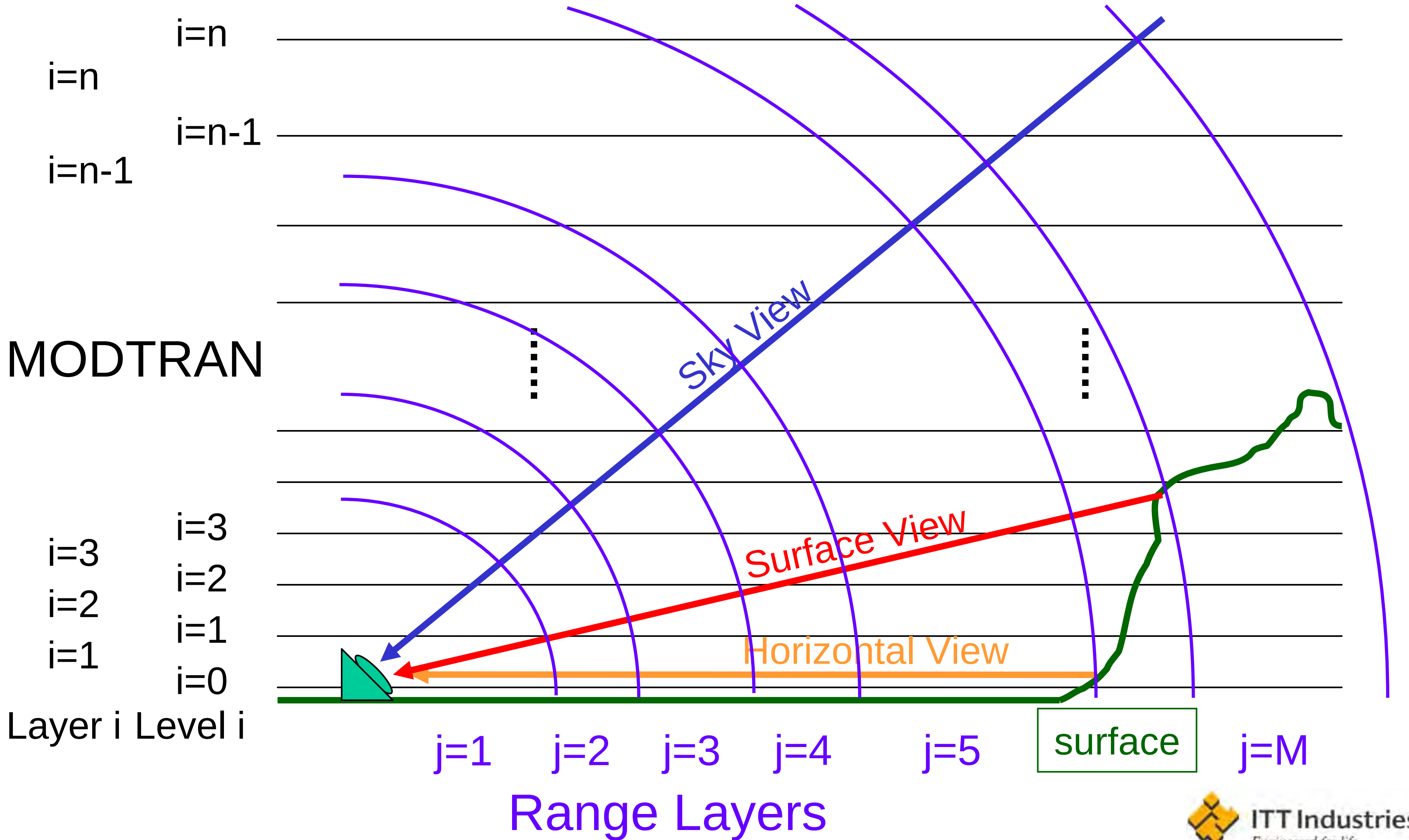
Radiative Transfer Method for Scene Simulation

- Plane-parallel, down-welling only, non-scattering
- Vertical Layer spectral transmission from MODTRAN
  - User defined atmosphere (not just US std or MLS)
    - Number of levels
    - Temperature, water vapor, pressure, and ozone profiles specified on vertical (height) levels
    - Background aerosols (rural, urban, etc)
  - Layer transmission is converted to layer mass extinction for use in SPEED model
- Agent cloud spectral absorption from PNNL IR library
- Background data from DIRSIG or hyperspectral sensor
- Agent cloud and interferent concentrations are user specified in any range layer
- Range layer coordinate system used for radiative transfer

Radiative Transfer Geometry



Radiative Transfer Model in Range Coordinates

$$t_j = \exp\left[-\sum_{k=1}^{K} \sigma_k \rho_k l_j\right] \qquad T_M = \prod_{j=1}^{M} t_j$$

$$L = \varepsilon_s B(\theta_s) T_M + \sum_{j=1}^{M} (1 - t_j) B(\theta_j) T_{j-1}$$

t_j is layer transmission
σ_k is mass extinction coefficient
ρ_k is density for k^{th} constituent
l_j is layer thickness of Range layer j
T_M is sensor to surface transmission

M specifies the number of layers between the sensor and the surface

B is the Planck function
θ_j is the temperature of layer j
ε is the emissivity of the surface
θ_s is the temperature of the surface
L is the at aperture radiance

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Surface Properties via Simulation - DIRSIG

- Surface properties of the scenes can be generated using the Digital Imaging and Remote Sensing Image Generation (DIRSIG) tool provided by the Rochester Institute of Technology
  - DIRSIG provides rendering and thermal modeling of complex, 3D scenes
  - Spectral data in DIRSIG is supplemented by the Advanced Spaceborne Thermal Emission and Reflection (ASTER) Radiometer Spectral Library (provided by Johns Hopkins University, the Jet Propulsion Laboratory, and the United States Geological Survey)
  - Each material file contained between 5 and 100 different emissivity curves to complicate the background spectra.

Surface Properties via Data Collections - SPARSE

- SPARSE algorithm – Surface Properties and Atmospheric State Estimator
- SPARSE does not depend on the presence of blackbodies in the scene
  - It estimates the atmospheric transmission spectrum in an optimal manner using the passive hyperspectral observations and *a priori* information about the surface and atmosphere
  - In addition to retrieving the atmospheric transmission spectrum for use in spectral matched filter applications, the SPASE also retrieves surface spectral emissivity and surface temperature
- SPASE is based on well-established work used in a variety of atmospheric retrieval applications
  - The primary difference between previous Bayesian atmospheric remote sensing methods and this implementation is that SPASE retrieves the transmission spectrum and not the geophysical state variables (along with model parameters) that describe it
  - Since one is only interested in the atmospheric transmission to generate obtain surface property signatures, there is no need to retrieve the atmospheric gas concentration profiles
  - The state variables necessary to describe the radiative transfer model are: atmospheric transmission spectrum, atmospheric temperature, surface emissivity spectrum, and surface temperature
    - Additionally, local variations of water vapor and carbon dioxide are accounted for by retrieving their a concentration-lengths (CLs)
    - These were included in order to get a better fit but may not be necessary for most applications.

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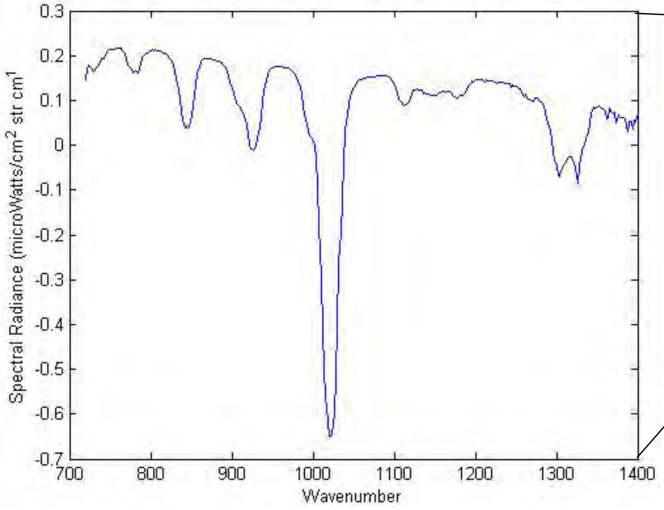
Scenario 1 - Downlooking Simulated Scene Using DIRSIG MegaScene

Difference Spectra – Off plume (blue) – On plume (red)



Composite Scene Showing Plume Locations

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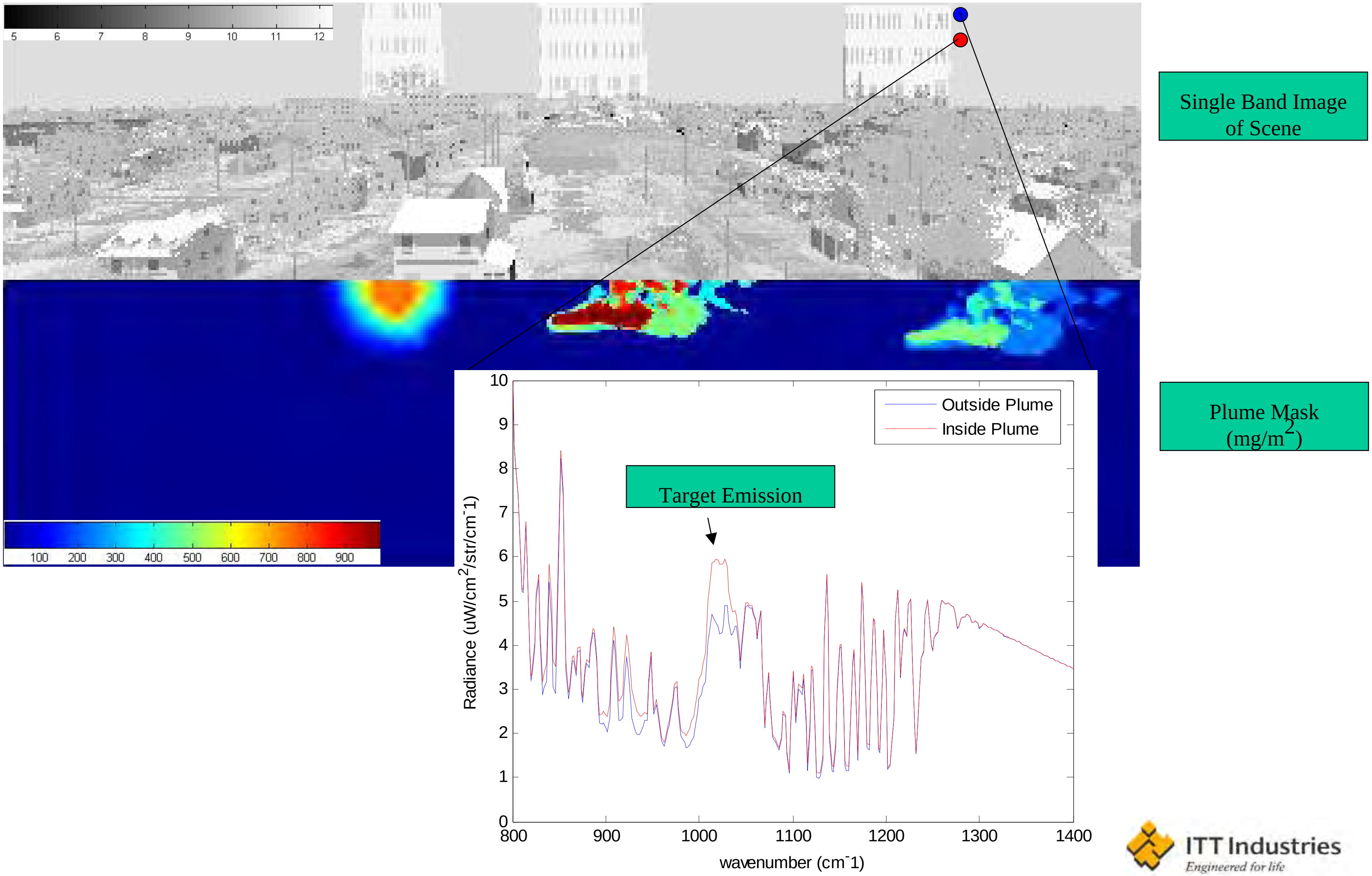
Discussion of Scenario 1 Simulation

- DIRSIG Did Not Have LWIR Spectra for Twelve (12) Materials in the Scene
  - We used spectra from ASTER database to supplement
  - Did not supply sufficient spectral variability
- Plume insertion looked realistic
  - Plumes were in absorption over a hot background; emission over cooler background
- Clear evidence of atmospheric water lines
- No ozone lines
  - Scene was developed as if the sensor was flying at 1 kilometer
  - Not enough atmospheric path to create a strong ozone signature

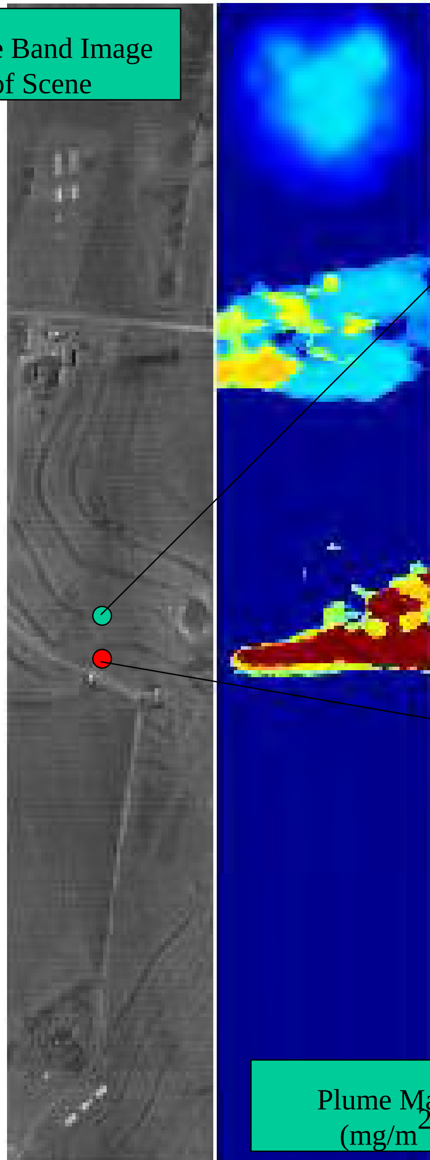
Scenario 2 - Horizontal Simulated Scene Using DIRSIG MegaScene

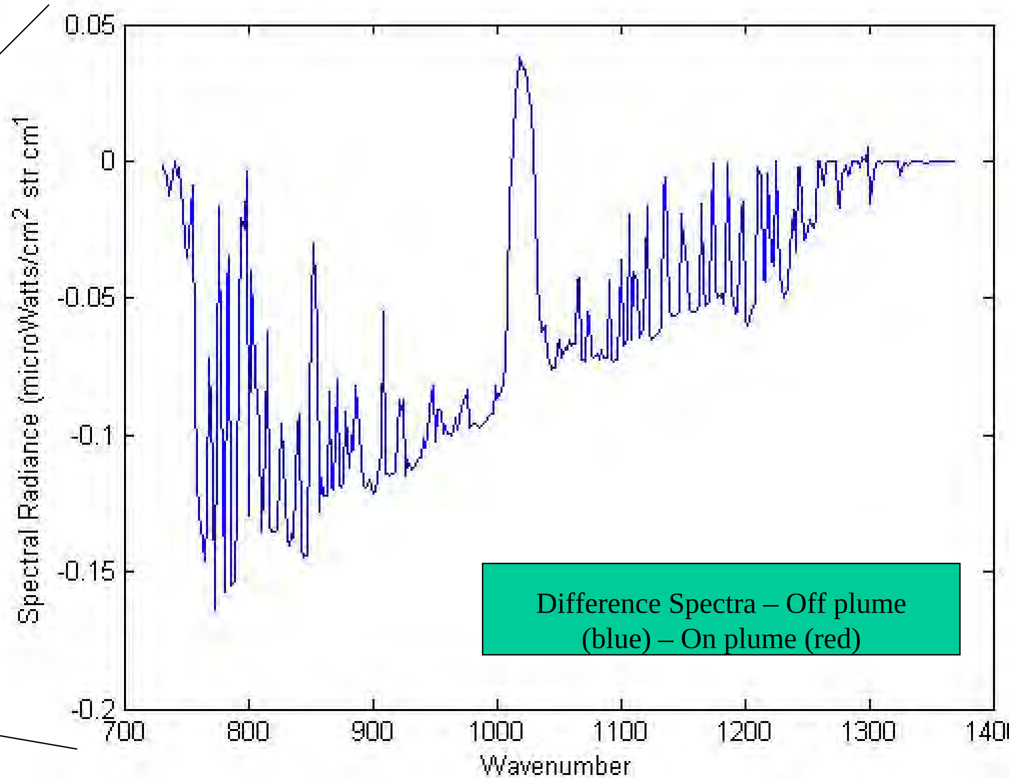


Discussion of Scenario 2 Simulation

- Difficulties Accurately Computing Radiative Transfer for Long Paths
  - Code was modified for horizontal geometries
  - Calculated the atmospheric layer attenuation using a vertical path
  - Applied the layer optical depths to the longer ranges required for the horizontal geometry
- Same Spectral Property Issues in LWIR Described in Scenario 1
- Significant Ozone Absorption for Low Elevation Angles / Long Ranges

Scenario 3 - Simulated Scene Using SPARSE Method to Define Background Properties from Measured Data



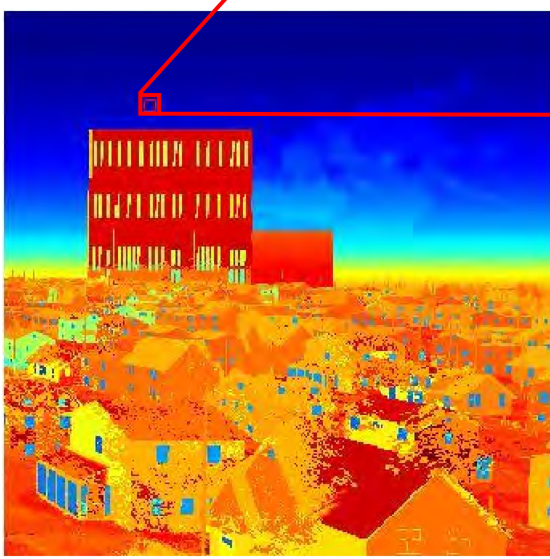


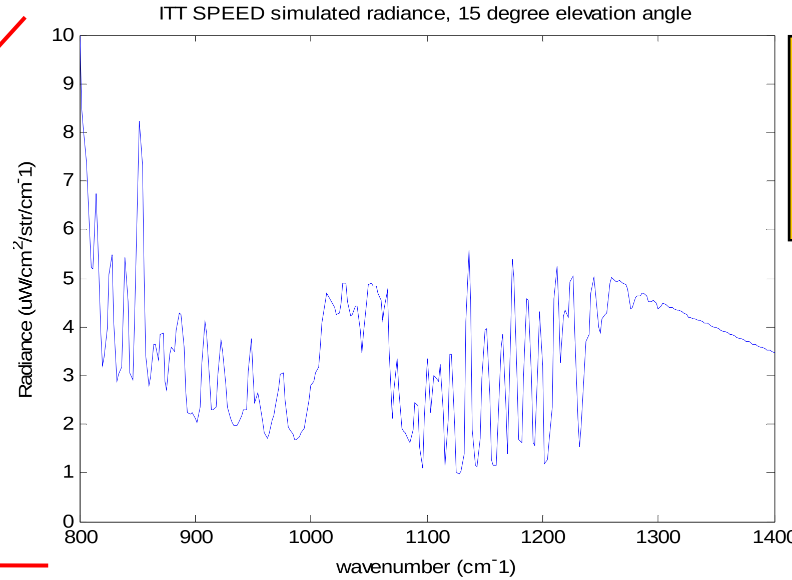
Discussion of Scenario 3 Simulation

- Surface Emissivity and Surface Temperature Retrieval is an Offline Process That Requires Human Interaction
- Sensor Noise and Weak Sensor Response can Affect the Retrieval
- This Method Provides the Most Realistic Background Clutter
- Simulated Atmosphere and Target Insertion Allows fro Different Scenarios to be Built from Same Input Deck

Comparing Simulated Horizontal Radiance to Measured Horizontal Radiance

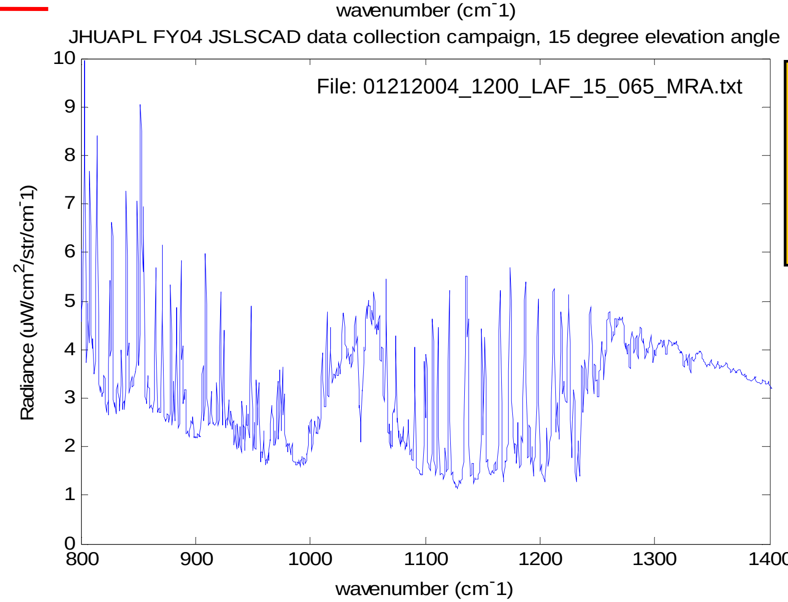
SPEED Simulated
Hyperspectral
Horizontal Scene





SPEED Simulated
15 Degree Elevation
Clear Sky Radiance

($2\ cm^{-1}$ resolution)



JHUAPL Measured
15 Degree Elevation
Clear Sky Radiance

($0.5\ cm^{-1}$ resolution)

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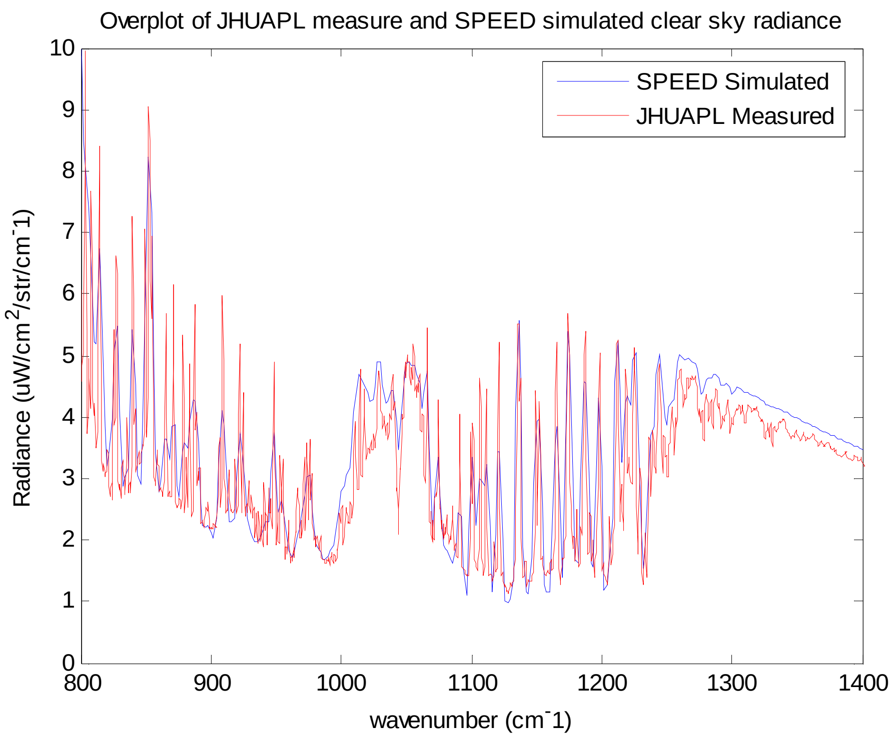
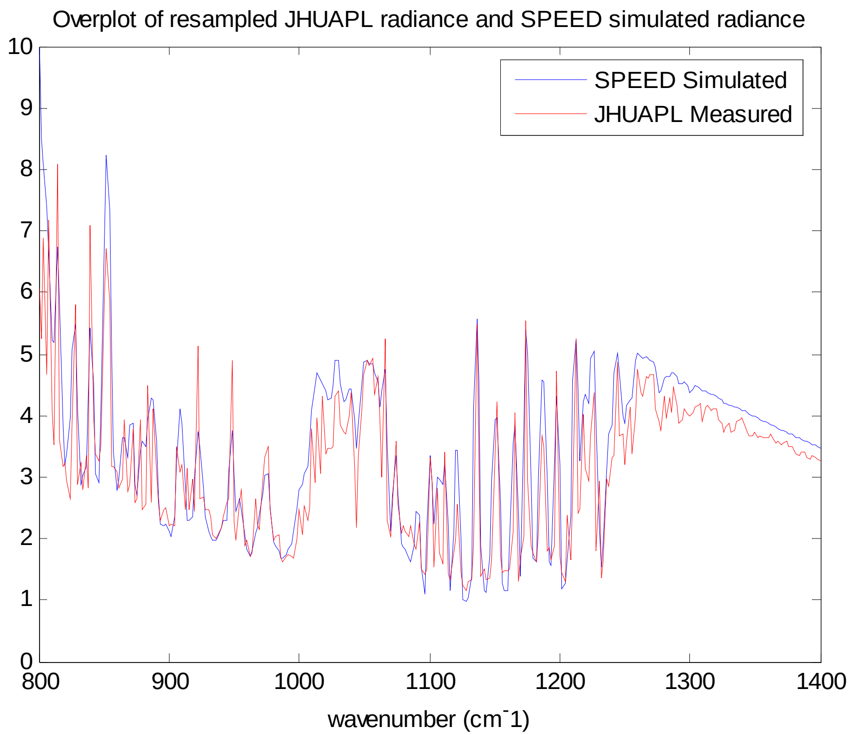
Measured vs Modeled Spectral Radiance at Consistent Resolution

Spectral Radiance Comparison
Native Resolution



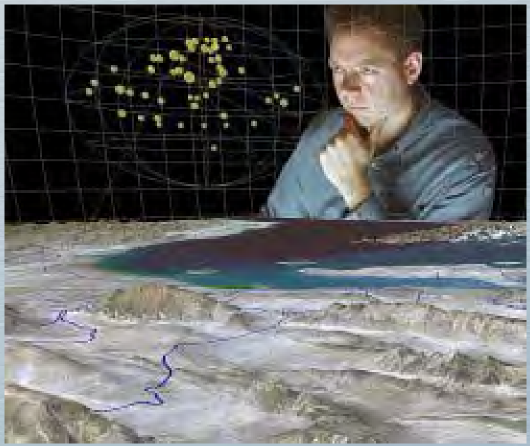
Spectral Radiance Comparison
JHUAPL Data Resampled to 2 cm^{-1}



Conclusions

- Simulated Scenes Can Be Used to Support Algorithm/System Development
- More Validation is Required to Define Accuracy of Simulation Processes
- Mixture of Simulations Methods Should be Utilized
  - Fully Simulated Backgrounds
    - Most Flexibility
    - Least Realistic
  - Background Properties Retrieved from Measured Data
    - Most Realistic Clutter
    - Limited by Data Sources

The Chemical and Biological Defense Information Analysis Center (CBIAC), a Knowledge Management Source for Authoritative Information



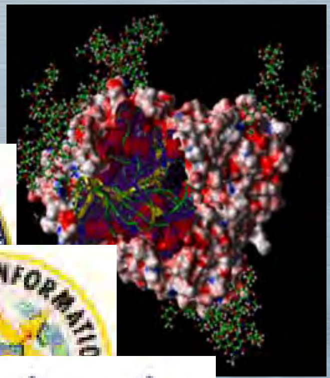
Donald McGonigle KM Program Manager

October 2005

Chemical and Biological Defense CBIAC Information Analysis Center

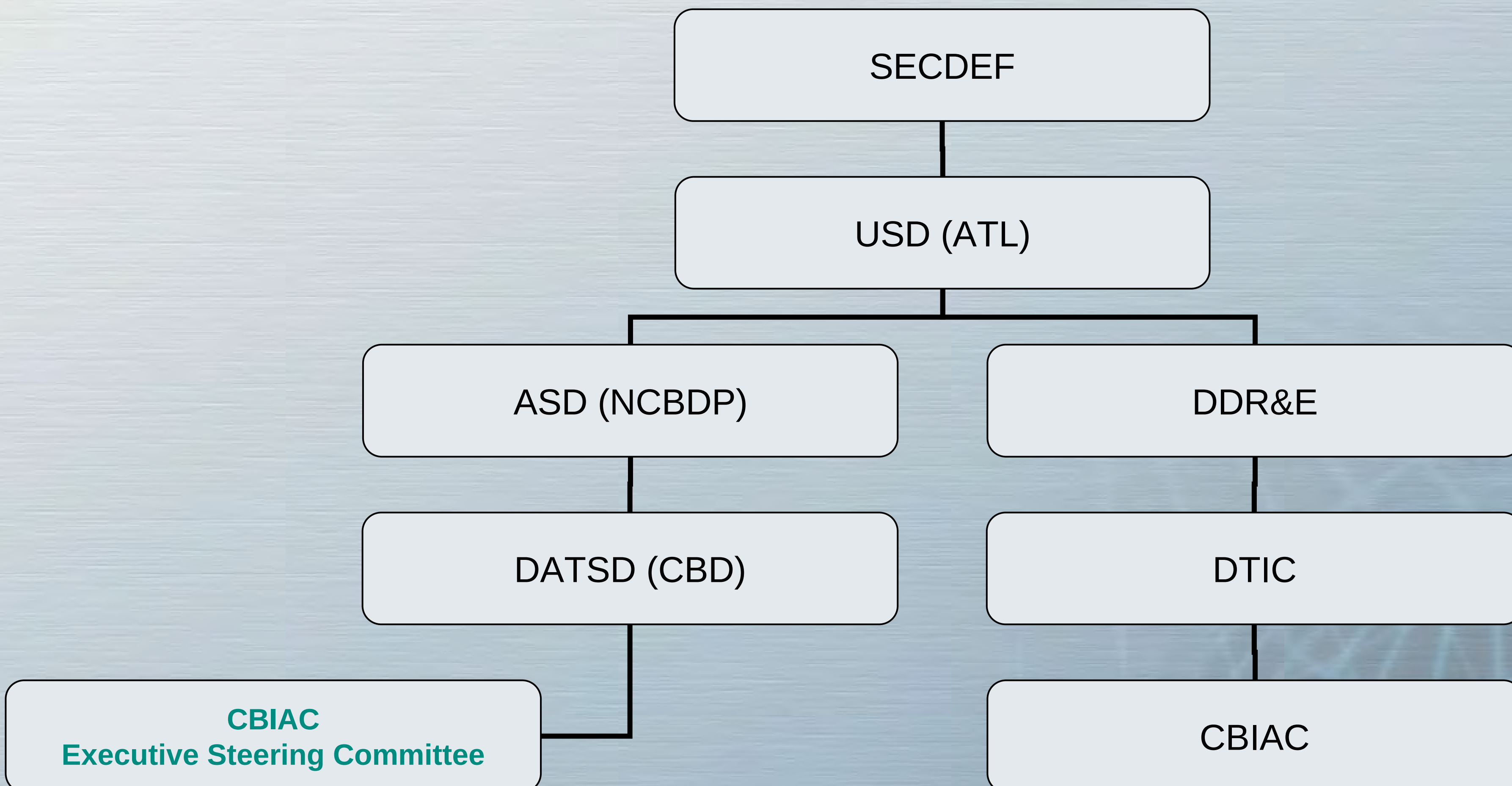
CBIAC Overview

- **Chartered by DoD to generate, collect, analyze and disseminate scientific and technical information to Gov't and their contractors**
- **Provides comprehensive databases, technical analysis, and analytical tools and techniques in the CBRNE domain**
- **Inquiries (Free)**
- **CBIAC Website http://www.cbiac.apgea.army.mil**
- **Contractor operated; administered by Defense Technical Information Center (DTIC)**



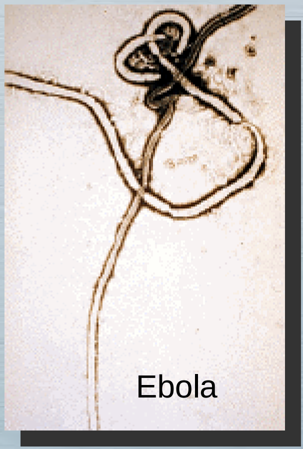
Chemical and Biological Defense CBIAC Information Analysis Center

CBIAC Relationships

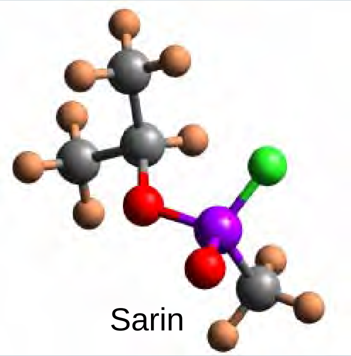


Technical Scope

- Chemical and Physical Properties of CW/CBD Materials
- Toxicology
- Warning and Identification
- Medical Effects and Treatment
- Treaty Verification
- International Technology, Proliferation and Control
- Individual and Collective Protection
- Chemical Identification
- Environmental Fate and Effects
- Decontamination
- NBC Survivability
- Combat Effectiveness
- Smoke and Obscurants



Ebola

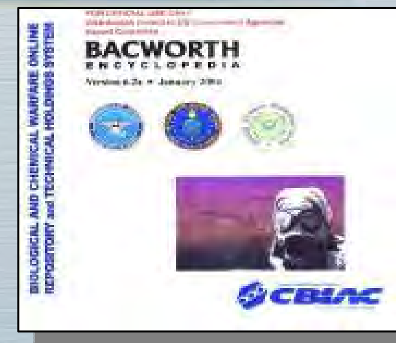


Sarin

- Demilitarization
- Analysis of Manufacturing Processes for NBC Systems
- Defense Conversion & Dual use Technology Transfer
- Domestic Preparedness / Homeland Security
- Force Protection
- Counterterrorism
- Counterproliferation
- Toxic Industrial Chemicals/Materials (TICs/TIMs)

Chemical and Biological Defense CBIAC Information Analysis Center

Core Program
Services and Products



- **Inquiries (Free)**
  - **Gateway to CBIAC expert reach-back**
  - **Informational, Technical, Bibliographic**
  - **Referrals**
- **CBIAC Website http://www.cbiac.apgea.army.mil**
  - **Access to Bibliographic Database (85,000 documents/128,000 citations)**
  - **Access to Inquiries, Products, Newsletters, etc.**
  - **Newsletters/Brochures**
- **Products (examples)**
  - **Criminal and Epidemiological Handbook**
  - **Sensing of CB Agents**
  - **Medical Biological Risk Assessment**
  - **CB Terminology Handbook**
  - **Susceptibility of Aerospace Materials to CW Agents**

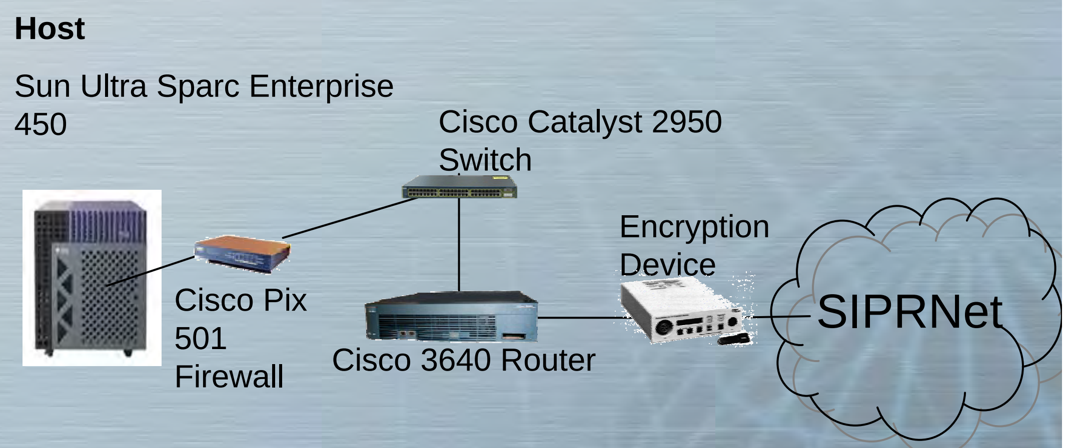
Chemical and Biological Defense CBIAC Information Analysis Center

Security

- **DSS Inspection: 3 Consecutive Superior Ratings**
- **CI Support Recognized**
- **Collateral Open Shelf Storage**
- **Self Certification for selected AIS**
- **SIPRnet Accreditation**
- **TS Closed Storage**

Application Management and Hosting Services

- **CBIAC Data Center**
  - Partnership with Aberdeen Proving Ground, DTRA, JRO, and DTIC
  - Physical Security
  - Backup Power/PDU
  - NIPRnet, SIPRnet
  - Multiple Carriers to Internet Backbone

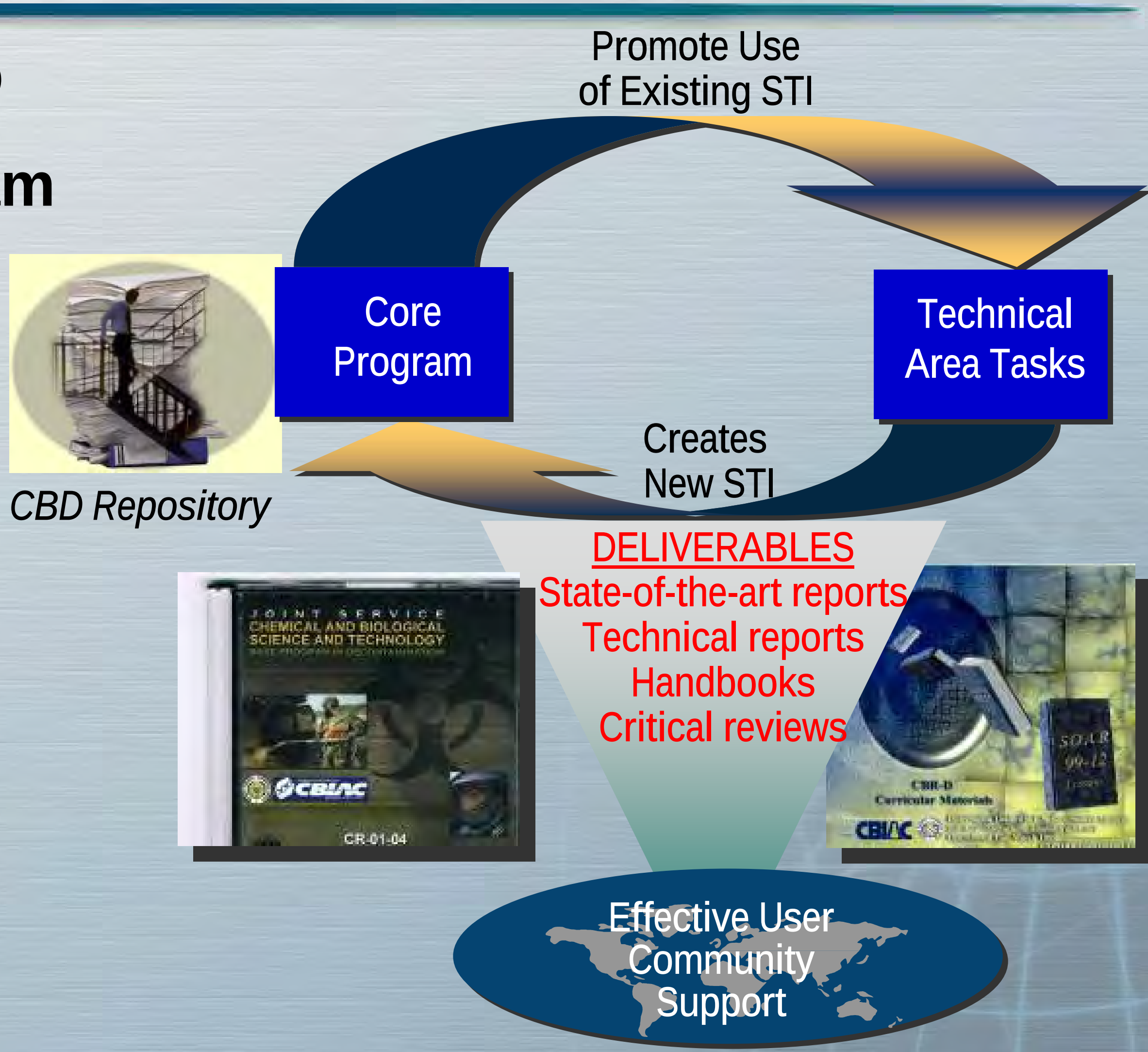


- **Off-site Backup**
  - Dugway Proving Ground
  - Commercial Facility

Chemical and Biological Defense CBIAC Information Analysis Center

Technical Area Task (TAT) Program

- **Utilize existing CBD Repository to support TAT program**
- **Create new Authoritative information to meet immediate user needs**
- **Ensure TAT deliverables incorporated into CBIAC CBD repository**
- **Leverage TAT data to support broader user needs/ applications**



CBIAC TATs – Customer Focus

- **Client controlled incremental funding**
- **Cost Plus Fixed Fee (you are only charged for work performed)**
- **Flexibility to change focus (within scope)**
  - Award provides a “menu” of relevant sub tasks
  - Broad Technical Scope
- **Work can be performed without Fiscal Year limitations**
- **Client provides on going direction and focus**
- **Can accept any “color” dollars**
- **Can accept dollars from multiple funding sources**

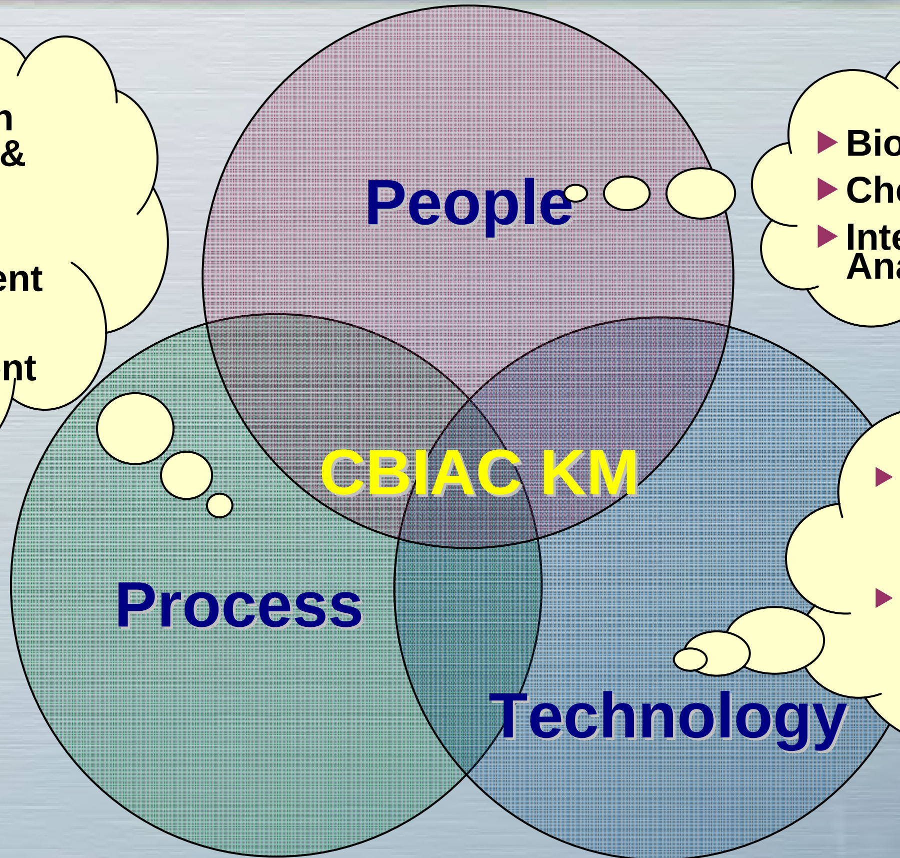
Knowledge Management

- **Provide science-based subject matter expertise to communicate, analyze, and distribute critical information assembled from multiple sources:**
  - Secure digital communications
  - Expert content development and distribution
  - Information visualization and discovery
  - Data acquisition and processing (animal tracking)
  - Epidemiologic mapping GIS/GPS
  - Database repository systems

Chemical and Biological Defense CBIAC Information Analysis Center

CBIAC Knowledge Management Elements

- Information Collection & Analysis
- Taxonomy Development
- Data Management



- Biologists
- Chemists
- Intelligence Analysts

- COTS Integration, Battelle Products (Starlight, Inspire, etc)
- Battelle Development (BACWORTH2, DART)

Decision making requires information that is
- **Authoritative**
- **High quality**
- **Relevant**

Chemical and Biological Defense CBIAC Information Analysis Center

KM Problem Areas/Client Challenges

- ***Need to improve data quality*** **to support and manage performance and enforcement of safety, project, and fiscal management business areas**
- ***Share and collaborate*** **amongst and between organizations**
- ***Large volumes of distributed data*** **in various formats and states**

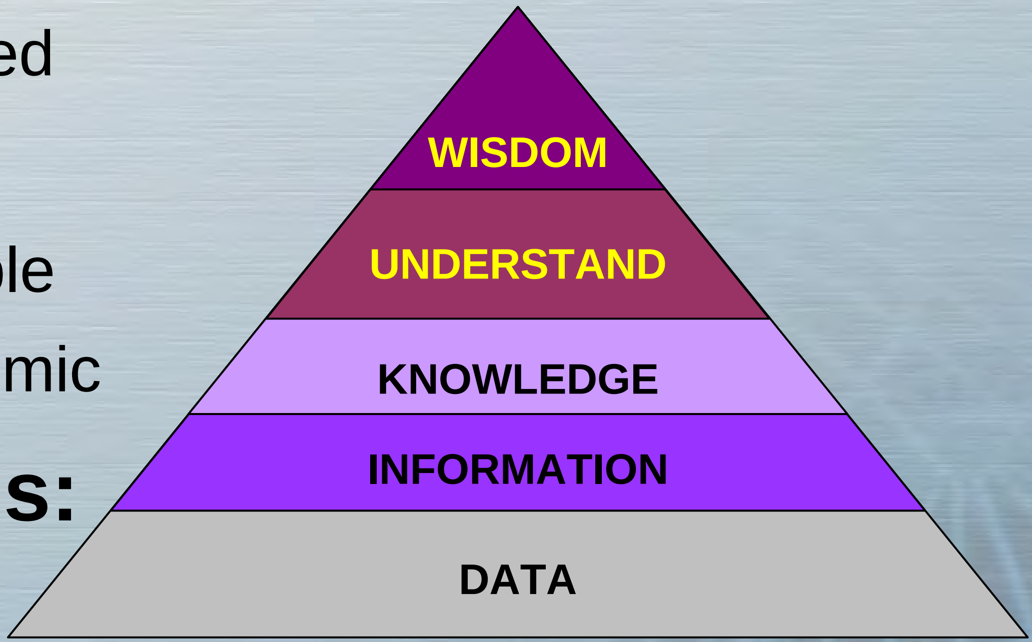
Age old problems that exist in many government agencies…

… some driven by legacy applications and technologies…

… others driven by culture differences or leadership

Data and Taxonomy Problem Space

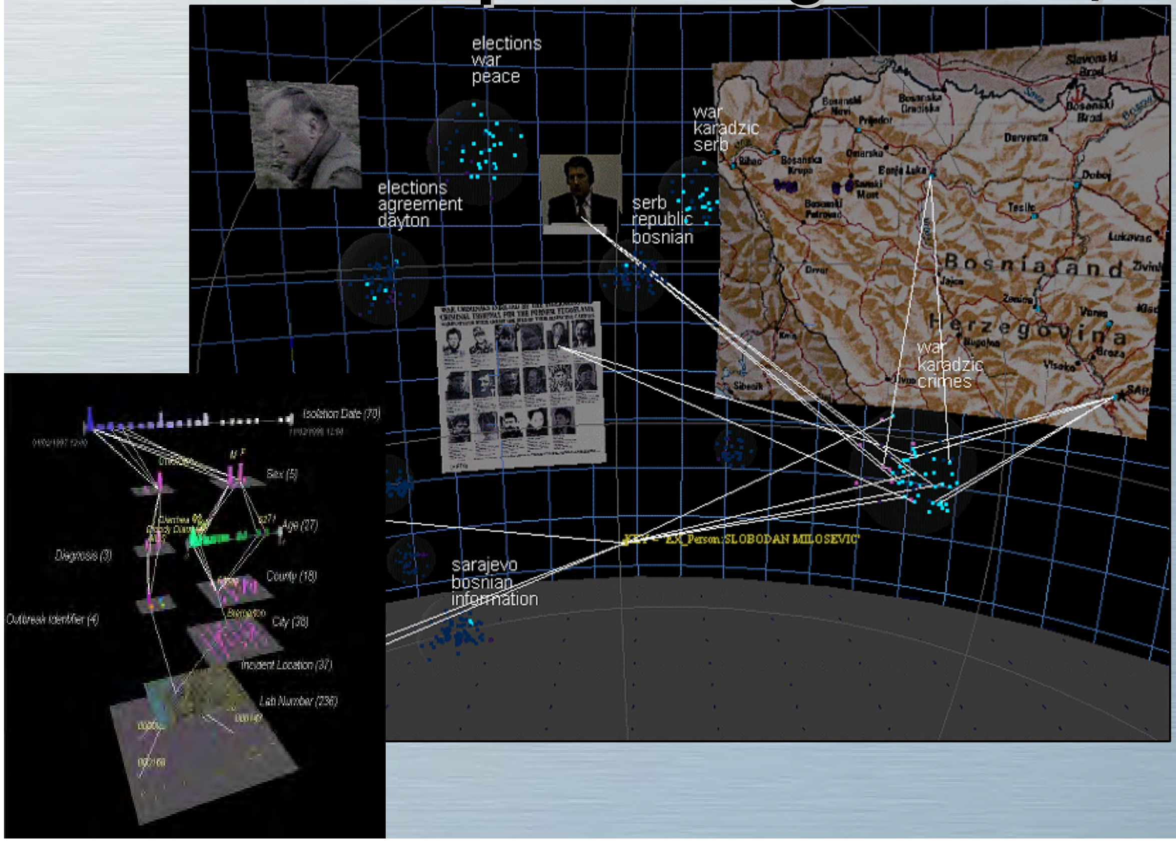
- **Two general data types**
  - Structured: generally numeric or E-R based
    - Unstructured: text based
  - Structured data is:
    - Easily machine readable
    - Countable and algorithmic
- **Unstructured data is:**
  - Human readable
  - Contextual and semantic
- **Large volumes / quantities of data**



Chemical and Biological Defense CBIAC Information Analysis Center

Starlight Information Visualization System

Organizes, characterizes, and integrates a variety of structured and unstructured information types, for analysis to find patterns and to identify relationships among events, actors and locations.



Key Features/Benefits:

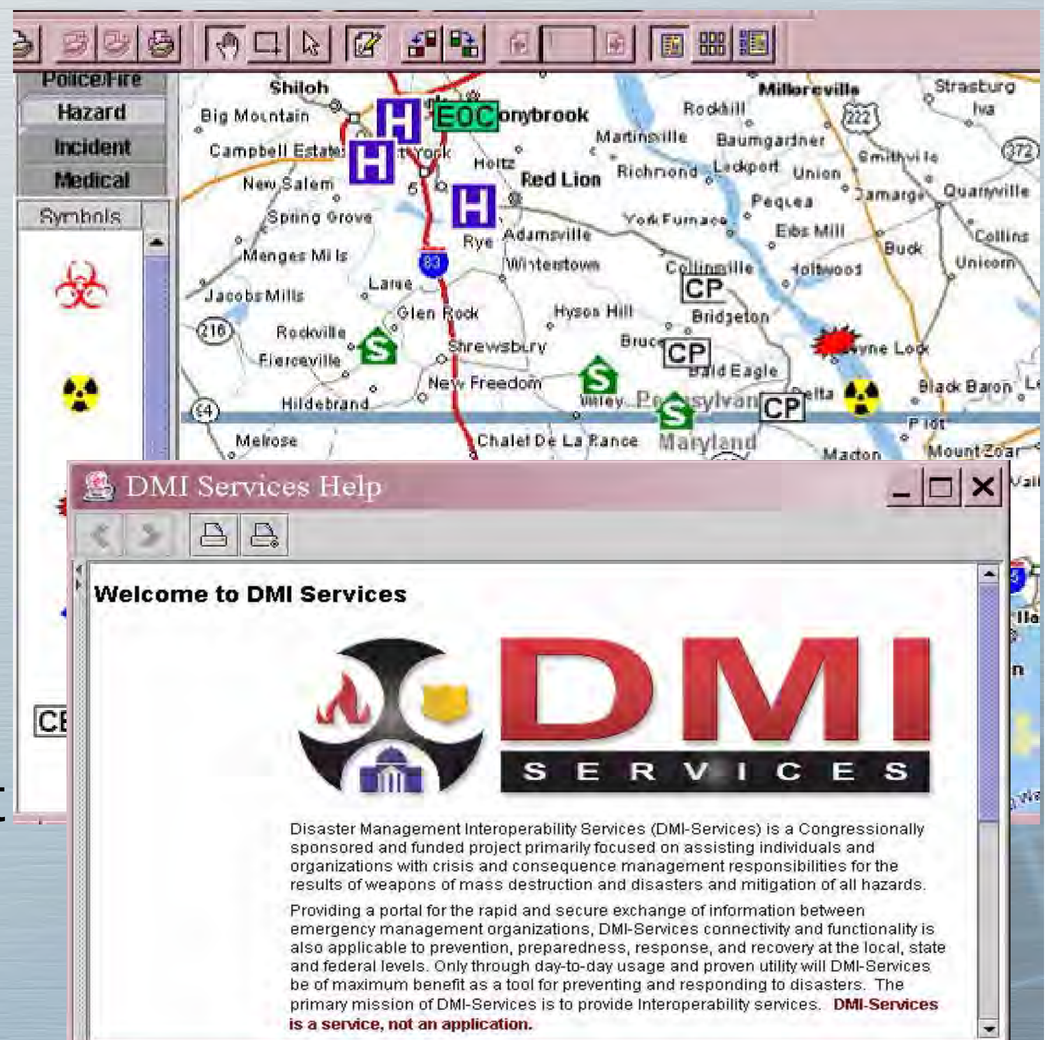
- Advanced information model
- Text information extraction
- Integrated GIS
- XML-based
- Information Integration
- Holistic Analysis
- Accelerated Interpretation
- Improved Understanding

Chemical and Biological Defense CBIAC Information Analysis Center

Disaster Management Interoperability-Services

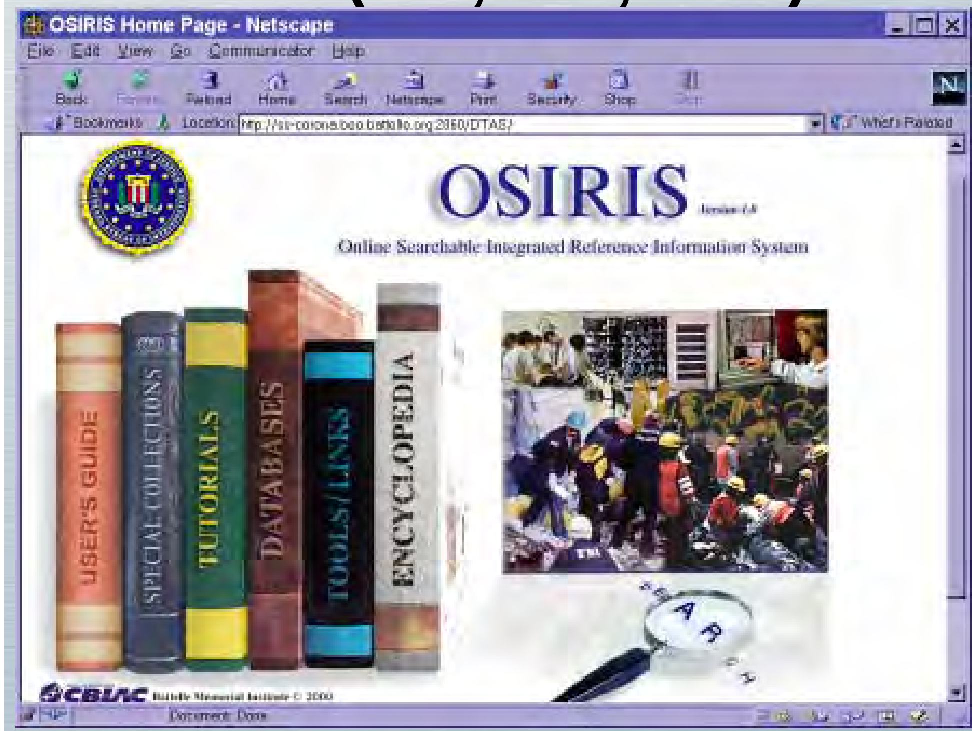
- **Primary Mission:**
  - Facilitate digital information sharing (interoperability) among the consequence mgt domains for all hazards
- **Secondary Mission:**
  - Provide basic tools at no cost for organizations that choose to use them

www.dmi-services.org



OSIRIS-BACWORTH2-BTCP

CB Repository - CBD Doc Collections, Analyst tools, in-depth Agent Encyclopedia, Threat Characterizations leverages CBIAC for CB recipe sources (FBI, DIA, DHS)



Agra Country Profile System

- **AGRA profiles foreign facilities and people linked to select animal diseases worldwide**
- **WIKI system supports collaborative input**

Summary

- **CBIAC addresses CBD and HLS issues**
- **Core Program**
  - No Cost Inquiry Support
  - Comprehensive Databases
  - Newsletters
  - State-of-the-Art Products
  - Gateway to CBIAC reach-back
  - “One-Stop Shop” Website
- **Technical Area Tasks**
  - Responsive
  - Easy to Use
- **Knowledge Management Capabilities**
- **CBIAC Focuses on Customer Service**

Your “One Stop Shop” for CBD/HLS Support

Sensor Data Fusion Working Group
28 October 2005
Albuquerque, NM

Tracking Atmospheric Plumes Using Stand-off Sensor Data

Prepared by:

Robert C. Brown, David Dussault, and Richard C. Miake-Lye
Aerodyne Research, Inc.
45 Manning Road
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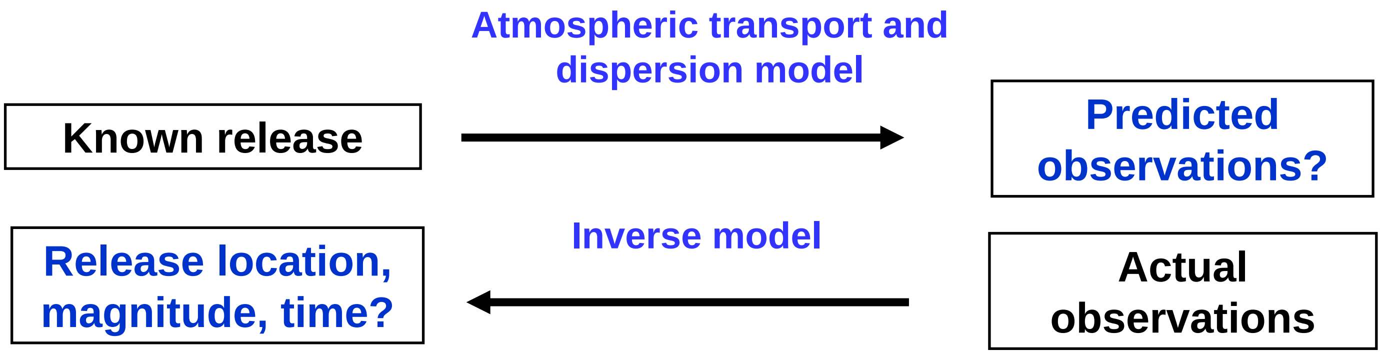
Patrick Heimbach
Department of Oceanography
Massachusetts Institute of Technology,
Cambridge, MA59717-3400 USA

The Inverse Problem



C. Wunsch, The Ocean Circulation Inverse Problem, Cambridge University Press,1996:

"An inverse problem, is one that is the inverse to a corresponding forward or direct one, interchanging the roles of at least some of the knowns and unknowns".

Fundamental aspect: the quantitative combination of theory and observation

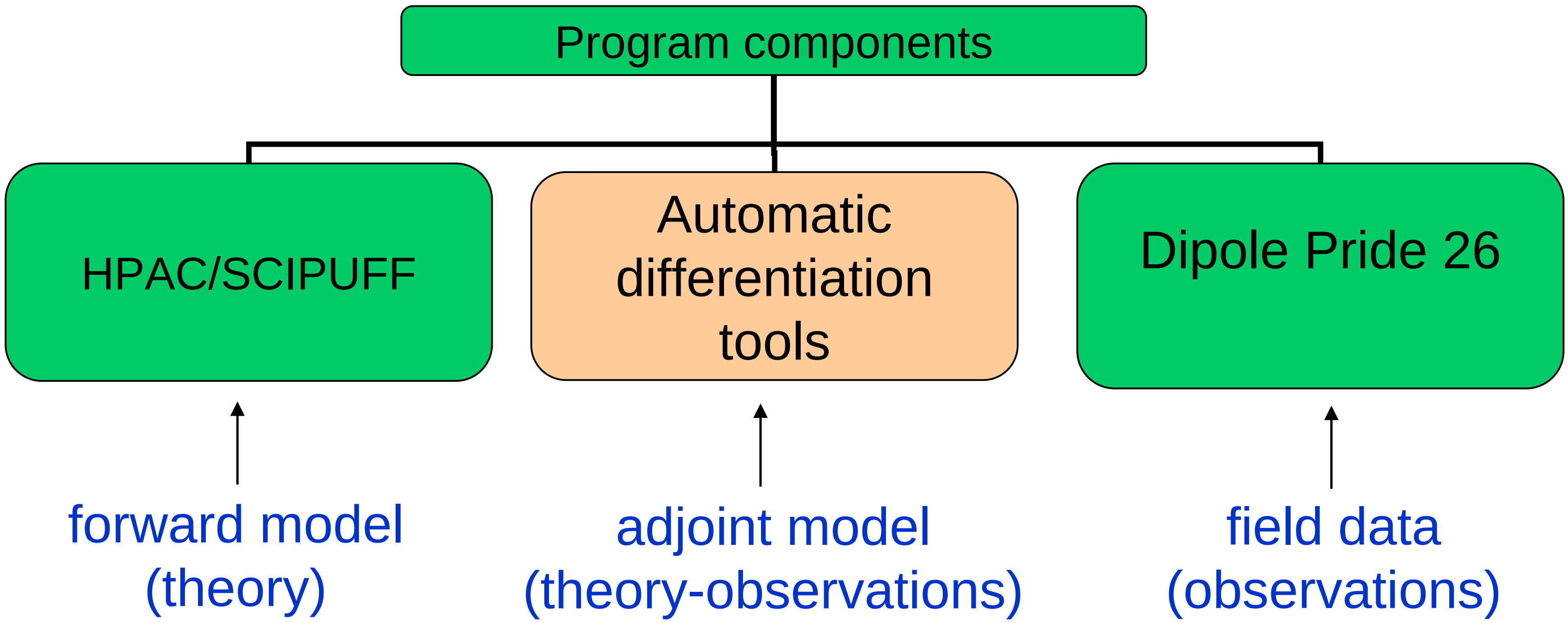
Adjoint Models

Numerical tools which provide the quantitative combination of theory and observations needed for the inverse modeling of physical systems.

- Adjoint model applications:
  - **Data assimilation: optimize model-to-data fit**
  - **Model tuning: optimize model equations**
  - **Sensitivity analysis: propagation of anomalies**

What We're Doing

Developing the adjoint model for a state-of-the-art atmospheric transport and dispersion model to characterize the source of a hazardous material release using stand-off detection data.



Automatic Differentiation

Adjoint and tangent-linear models are developed directly from the numerical code for the dynamical model.

$$\vec{\lambda}(t) = M_{\Lambda} M_{\Lambda-1} \cdots\cdots M_0 \bullet \left(\vec{\beta}\right) \qquad \delta^* \beta = M_0^T M_1^T \ldots M_{\Lambda}^T \bullet \left(\delta^* \vec{\lambda}\right)$$

Giering, Ralf and Kaminski, Thomas, Recipes for Adjoint Code Construction, ACM Trans on Math. Software, 24, 437-474, 1998.

Each line of code is view as an elementary operator M_{Λ}

$\rightarrow$ use rules for ordinary differenti ation

$\rightarrow$ code for elementary Jacobians

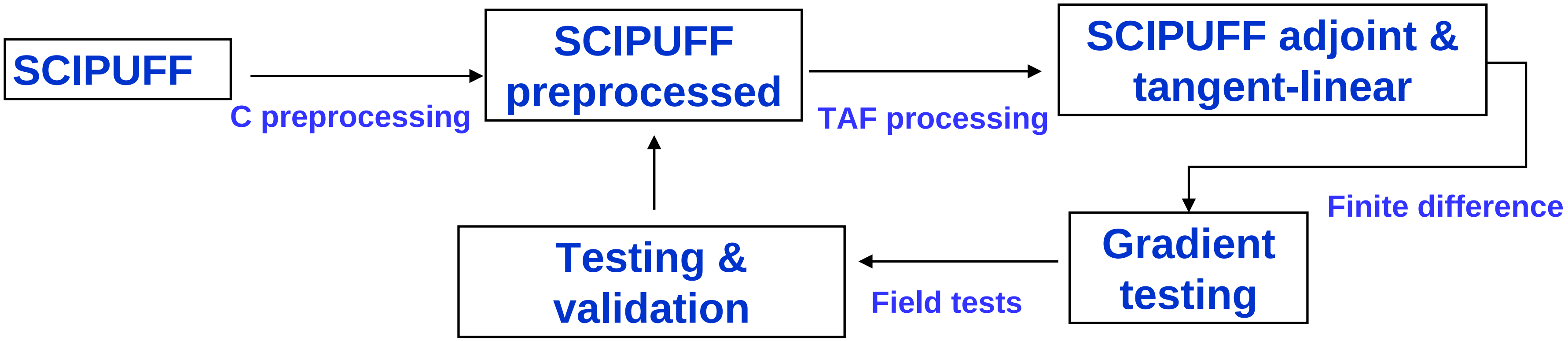
$\rightarrow$ use chain rule to compose M_{Λ}

Second-order Closure Integrated Puff (SCIPUFF)

- Features
  - Lagrangian Gaussian puff model.
  - Ensemble-average dispersion and a measure of the concentration field variability.
  - Second-order turbulence closure techniques
    - Relates dispersion rates to turbulent velocity statistics
    - Predicts statistical variance in the concentration field
  - Complete moment-tensor description
    - Wind shear distortion
    - Puff splitting algorithm and multi-grid adaptive merging algorithm
  - Adaptive time stepping scheme

Sykes, R.I., W.S. Lewellen, and S.F. Parker, "A Gaussian Plume Model of Atmospheric Dispersion Based on Second-Order Closure", J. Clim. Appl. Met., 25, 322-331, 1986.

SCIPUFF Adjoint & Tangent-Linear Models



- Incident
  - Single source, instantaneous
- Control variables
  - Single source latitude & longitude
  - Mass
  - Release time
- Dynamics
  - Single puff
  - Centroid evolution
  - Turbulent diffusion
  - Buoyancy
- Required code
  - File handling and data I/O
  - Meteorology routines
  - Materials
- Utility code
  - Drivers
  - Newton-Krylov minimization
- Not included
  - Puff splitting
  - Adaptive time stepping

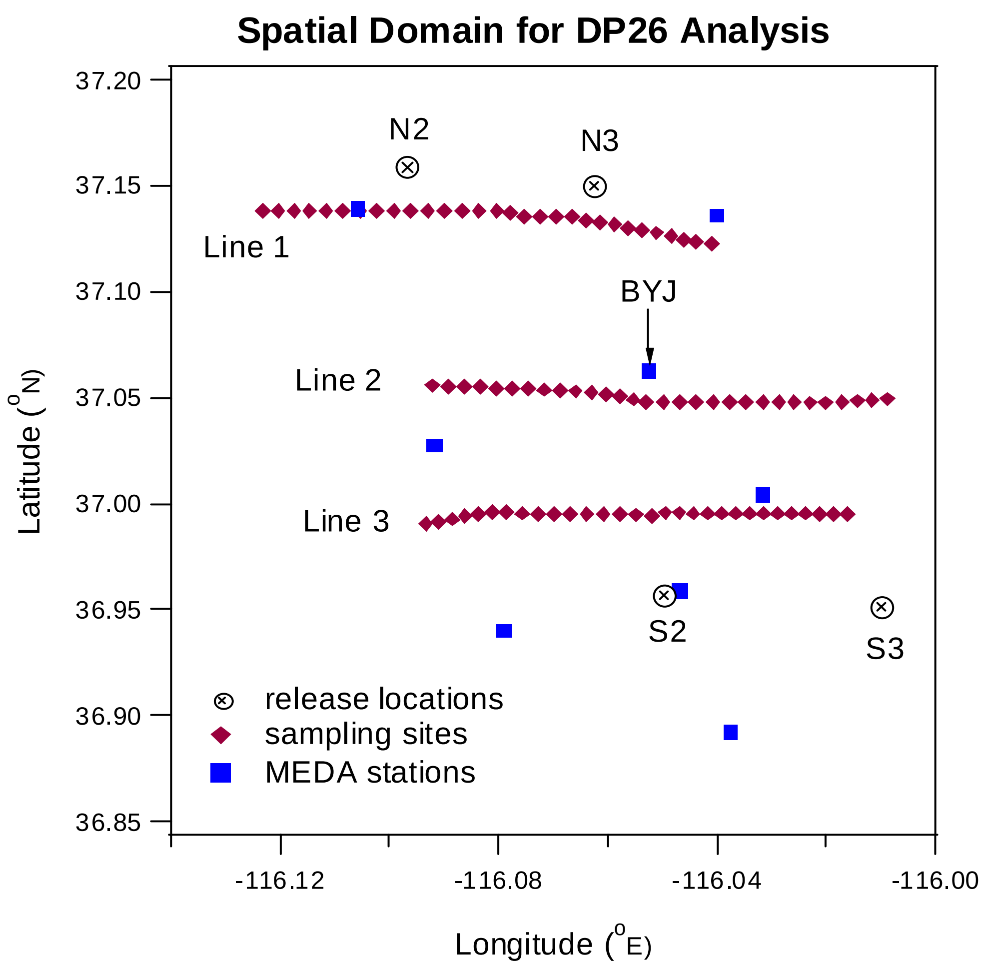
Dipole Pride 26 (DP26) Field Tests

- Defense Special Weapons Agency (DSWA) Transport and Dispersion Model Validation Program Phase II
  - To acquire data for the validation of integrated mesoscale wind field and dispersion model, in particular the HPAC model suite.
  - Conducted at Yucca Flat on the Nevada Test Site.
  - SF_6 tracer gas release with downwind tracer sampling at distances ranging to 20 km, along with extensive meteorological measurements.
  - Lateral and along-wind puff dispersion obtained from tracer concentration measurements.

C.A. Biltoft, "Dipole Pride 26: Phase II of Defense Special Weapons Agency Transport and Dispersion Model Validation," DPG-FR-97-058, Dugway Proving Ground, Dugway UT, July, 1998.

DP26 Test Site and Facilities

- Yucca Flat test site
  - North-south oriented basin
  - 30 km long and 12 km wide.
  - Yucca Lake (1195 m above mean sea level (MSL) is lowest point and the basin slopes upward to the north.
  - Basin surrounded by mountains: 1500 m (east) to 1800 m (west/north) MSL).
- Facilities
  - MEDA: network of meteorological data stations.
  - BJY: Buster-Jangle intersection.
- Whole air samplers
  - Three sampling lines; 30 samplers per line; 12 bags per sampler – 15 minute resolution.

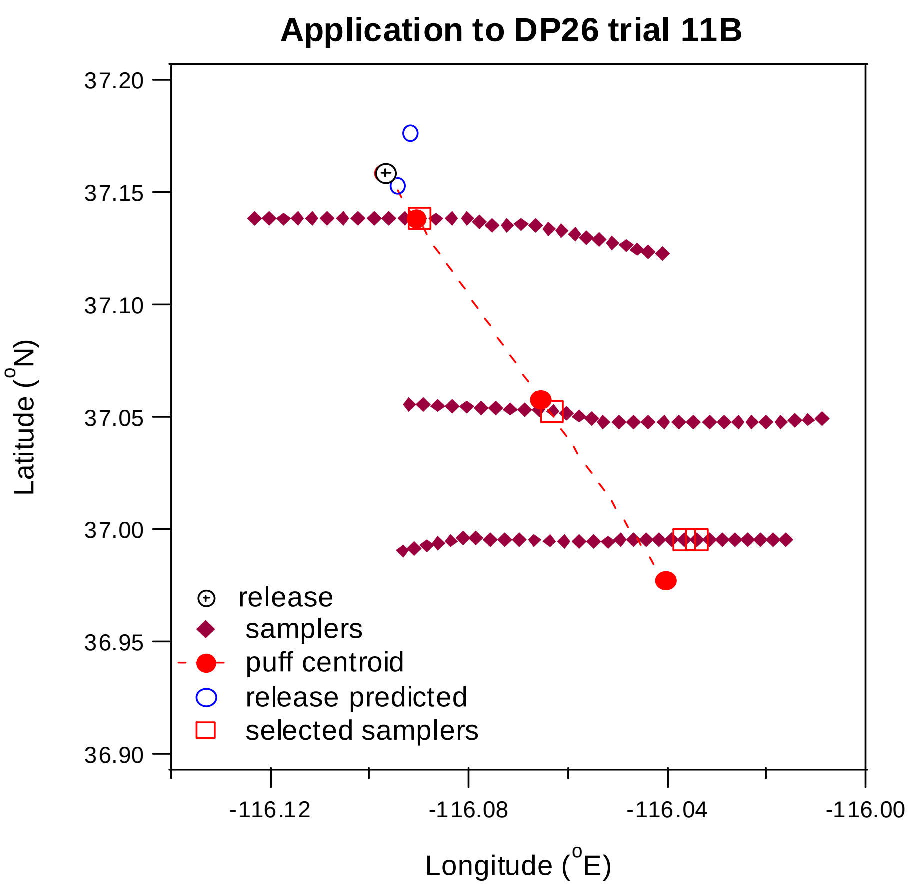


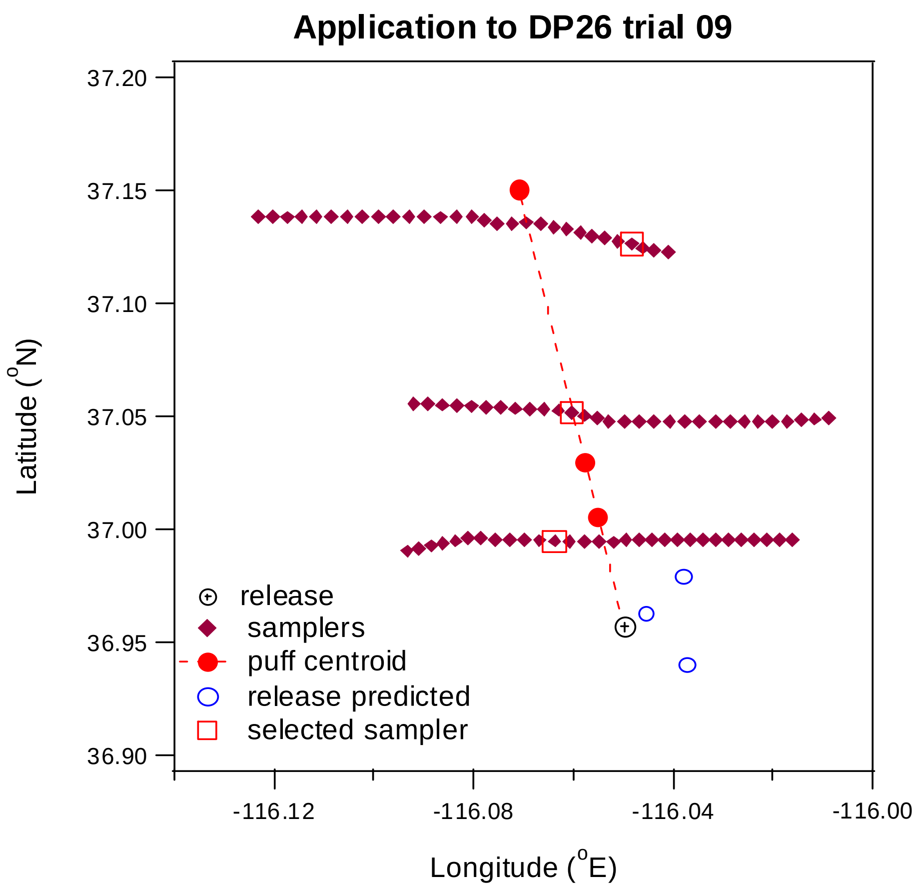
SCIPUFF Adjoint - Application to DP26

- Fixed puff width, fixed wind - not discussed
- Fixed wind
  - Controls – release latitude and longitude
  - Samplers – along a given sampling line with concentrations > 90% of the peak concentration.
- Variable wind field
  - Controls – release latitude and longitude
  - Samplers – along a given sampling line with concentrations > 10% of the peak concentration.
- Variable wind field, release time - not discussed
  - Controls – release latitude, longitude, and (manual) time.
  - Samplers – a given sampling line with conc’ns > 0.

Fixed Wind Adjoint Model

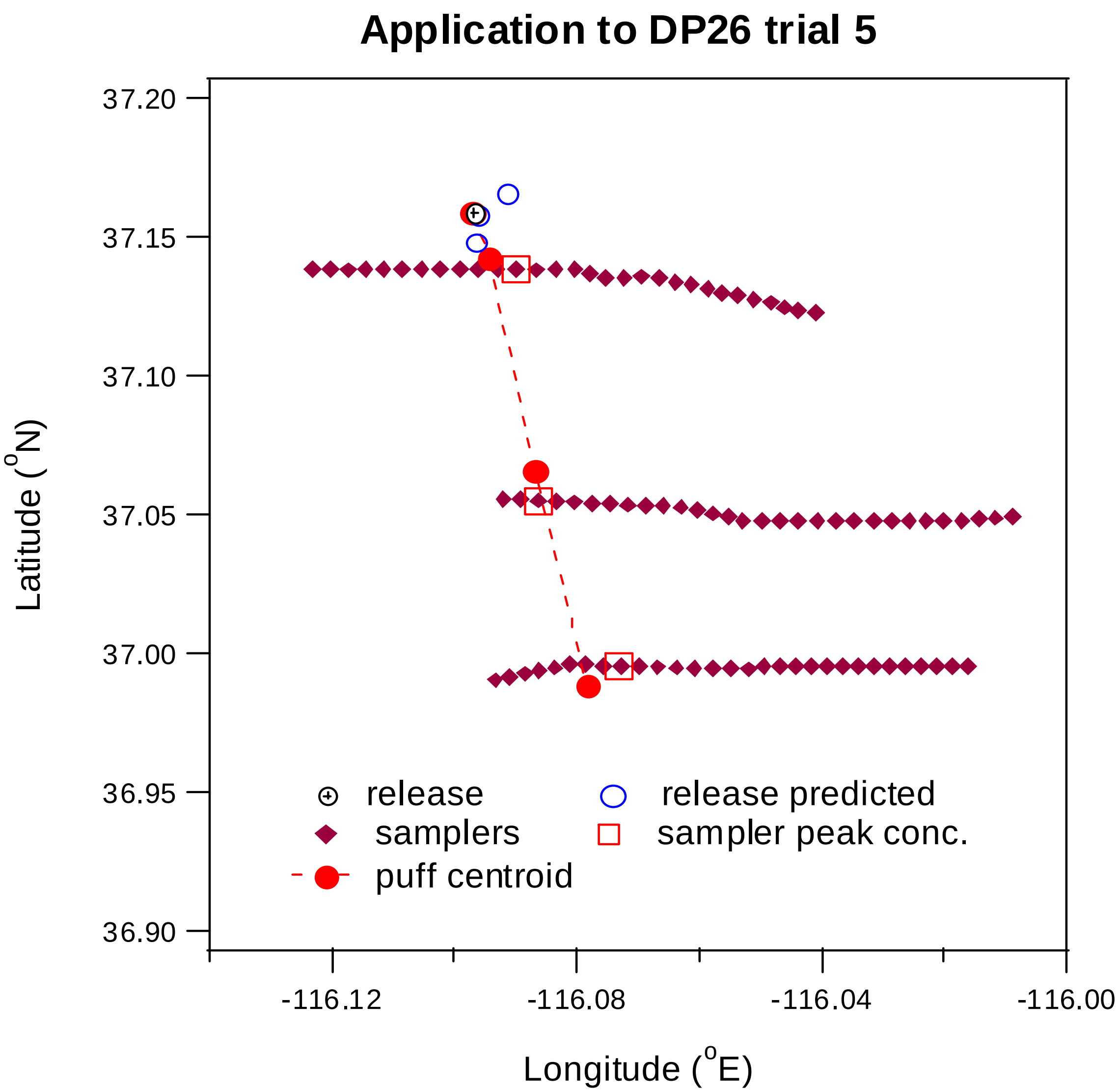
One estimated release location for each sampling line.

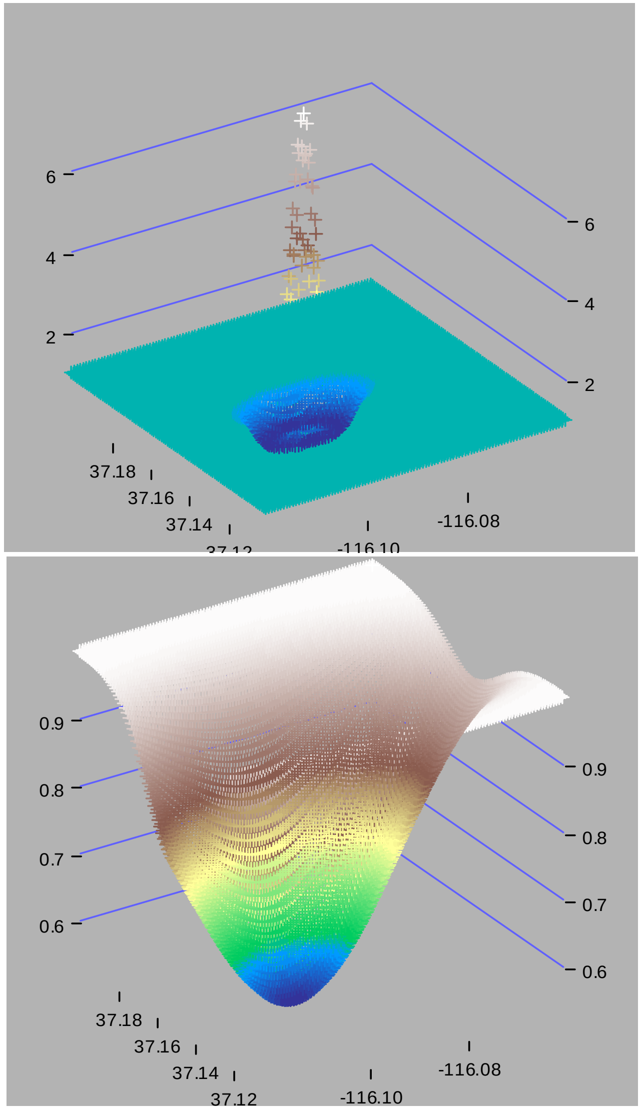




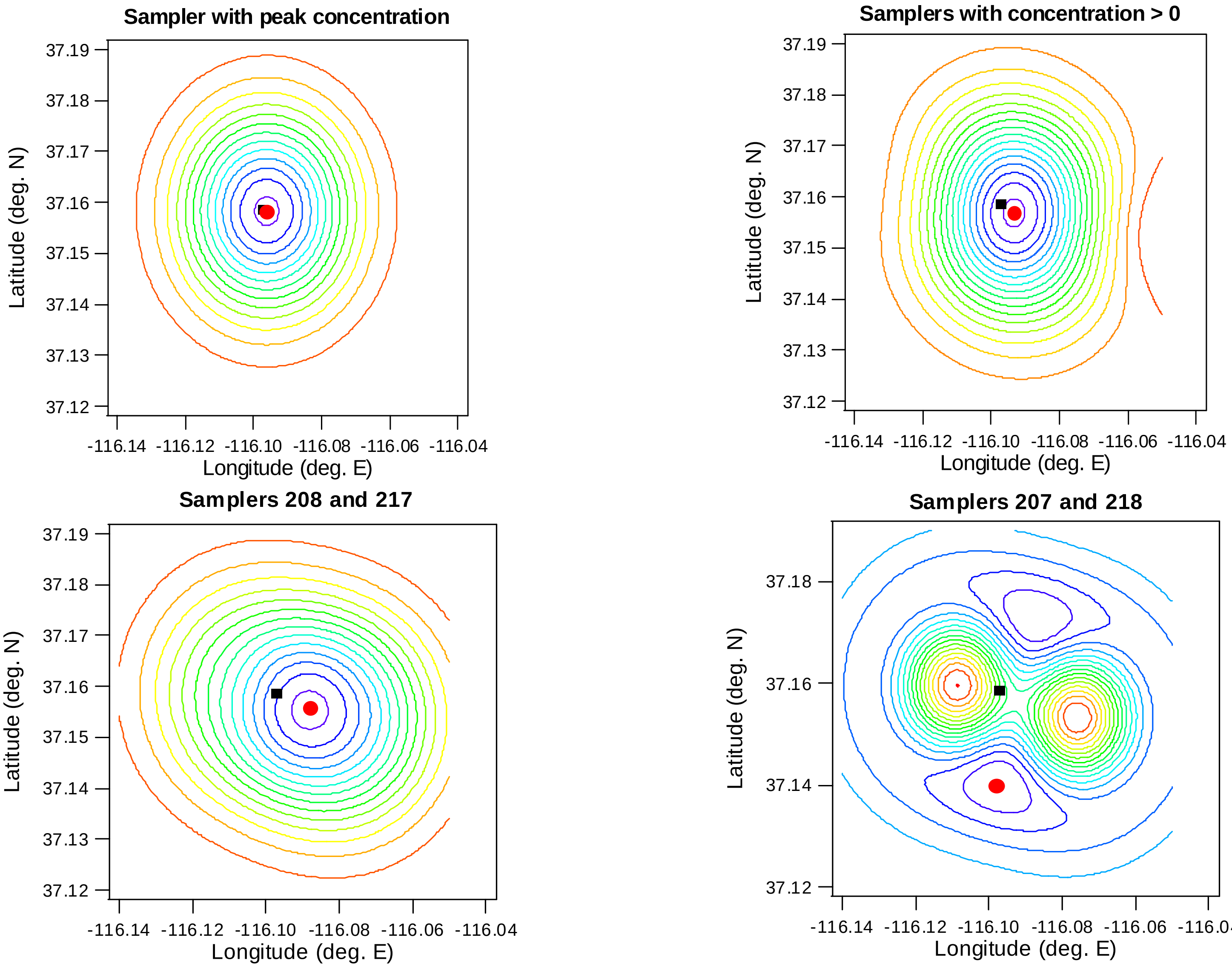
Aerodyne Research, Inc.

Fixed Wind Adjoint Model

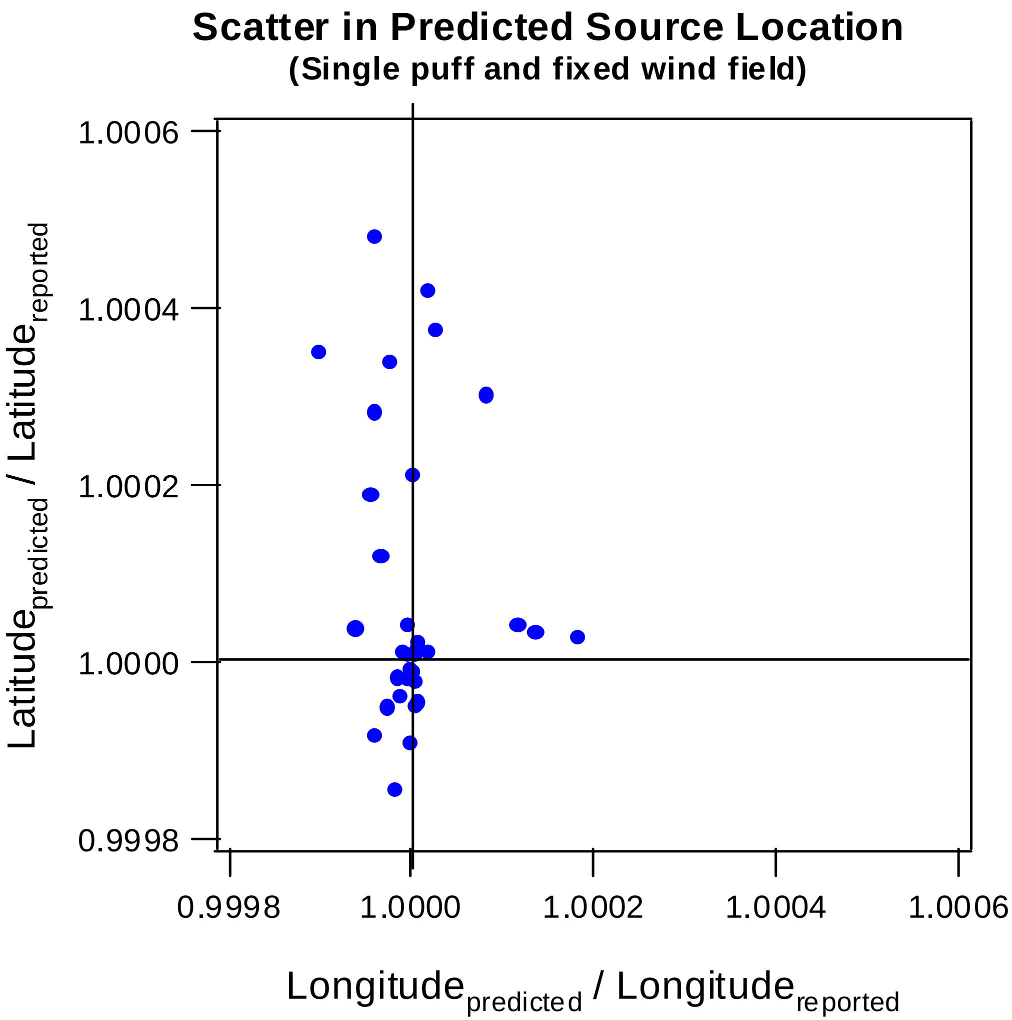




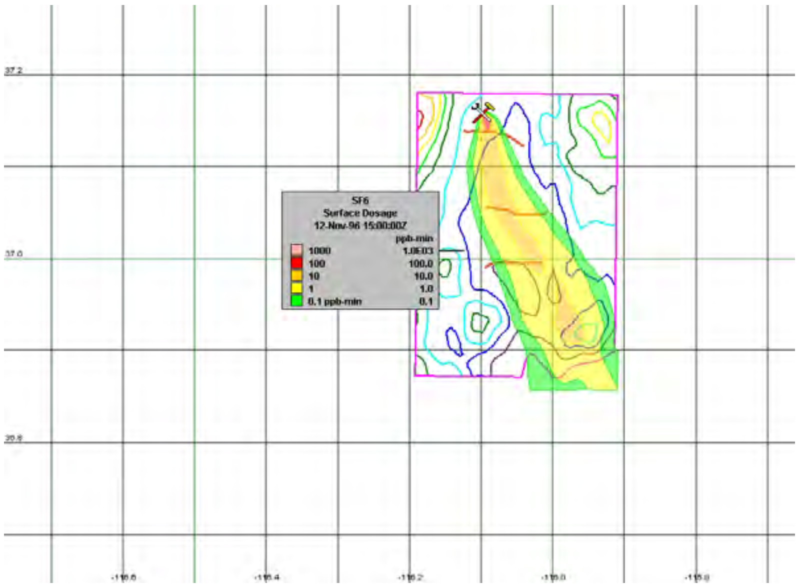
Cost Function: Fixed Wind DP26 Trial 11B – Line 2

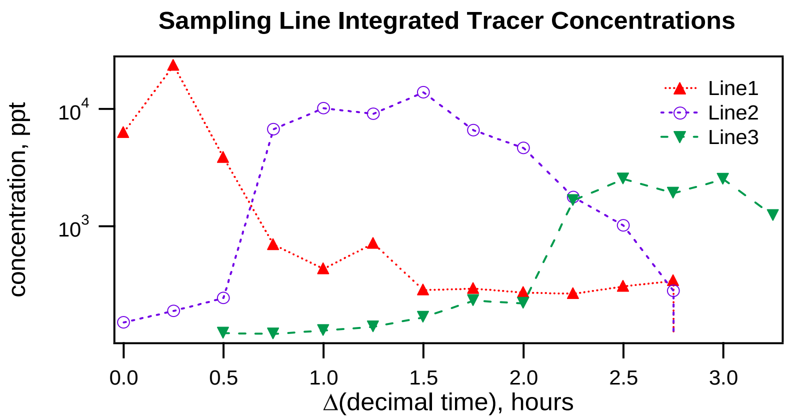


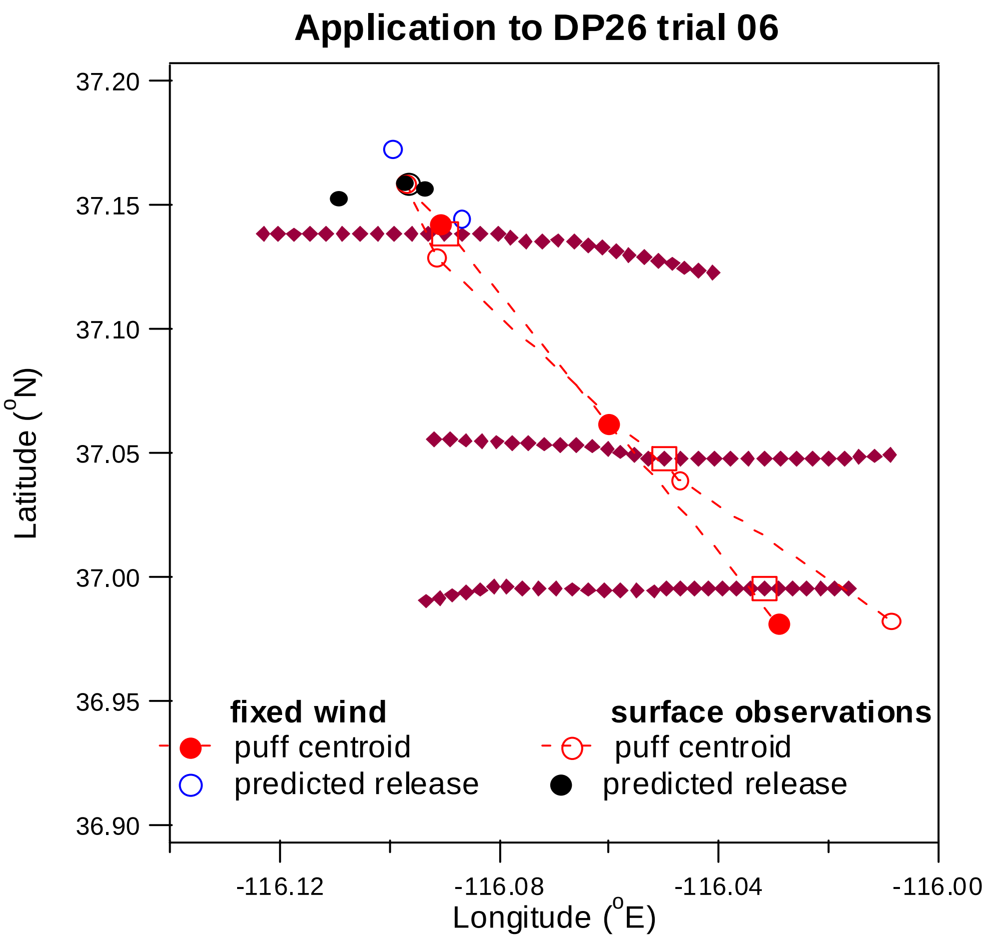
SCIPUFF (Fixed Wind) Adjoint Summary



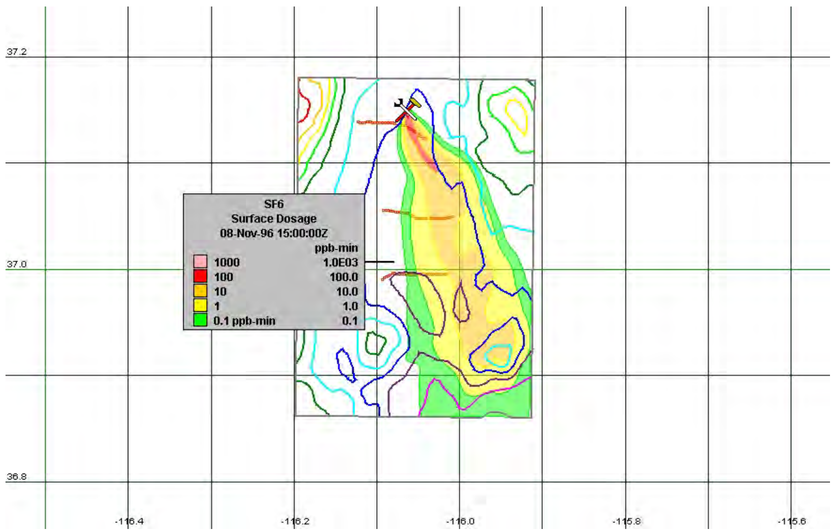
Fixed Versus Variable Wind Adjoint

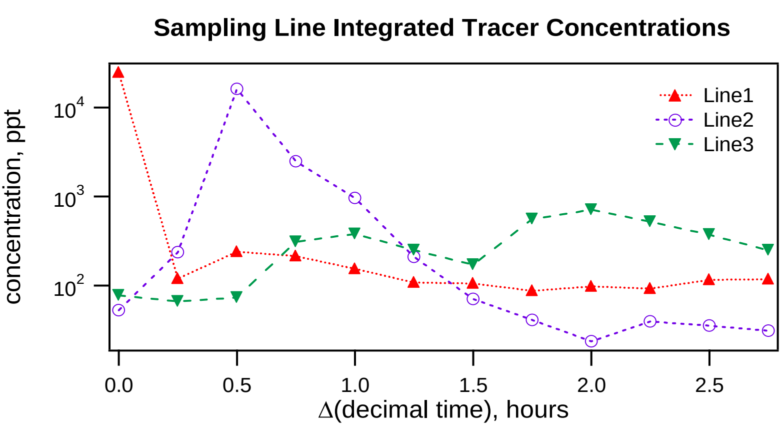


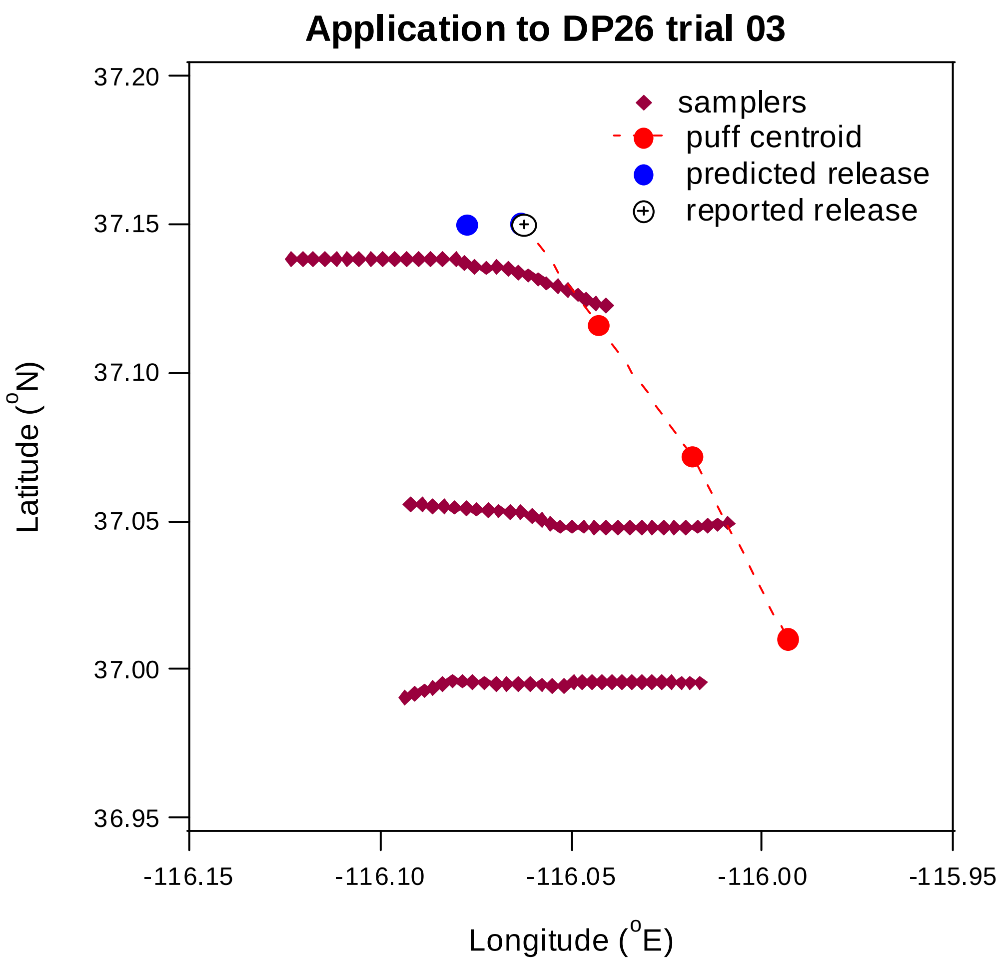




Variable Wind Adjoint







Future Work, Broad research objectives

- More fully develop theoretical and numerical foundation for source location approaches, using adjoint model with ‘ideal’ observable data
  - observational data requirements
  - sensor spatial resolution
  - the impact of faulty observational data
  - atmospheric transport and dispersion spatial range
- Incorporate measurement and model uncertainties
- Testing and validation using actual field data to ensure reliability and fully assess performance.

Future Work, Three year effort

- First year: extend SCIPUFF adjoint to enable source location using ideal observational data.
- Second year: incorporate ***measurement uncertainties***, begin testing using field data.
- Third year: treat ***model uncertainties*** and continue testing and validation using field data.
- Successful completion: numerical code, tested against field data,
  - implements adjoint-based strategies
  - locates hazardous release using observational data
  - includes estimated uncertainties in predictions

First Year Work

- Focus on adjoint model development
  - extend the SCIPUFF adjoint model for source location applications
  - use ideal or model simulated observational data
- Apply adjoint model to 'ideal' observable data to be address:
  - observational data requirements,
  - sensor spatial resolution,
  - the impact of faulty observational data
  - atmospheric transport and dispersion spatial range.
- Compare approaches for applying adjoint models in source location applications.

Acknowledgments

- Allan Reiter (DTRA) and Rick Fry (DTRA) – programmatic support
- Scott Bradley (DTRA) – Dipole Pride 26 data
- Jim Hurd (Northup Grumman) – technical support and coordination
- Ian Sykes and Biswanath Chowdhury (Titan) – SCIPUFF Atmospheric Transport and Dispersion Code

Transformation of Algorithms in Fortran (TAF)

- Commercial source code – to – source code translator
  - Giering, Ralf and Kaminski, Thomas, Transformation of Algorithms in Fortran, TAF Version 1.5, FastOpt, http://www.FastOpt.com, July 3, 2003.
- Features
  - Tangent-linear and adjoint models - 1st derivatives.
  - Hessian code - 2nd derivatives.
- Estimating the Circulation and Climate of the Oceans (ECCO)
  - Large data assimilation effort by MIT, SCRIPPS, NASA\JPL, and international collaborators: http://www.ecco-group.org.
  - Based on the MIT GCM (global, 3-dimensional NS solver): http://www.mitgcm.org.
  - ~100,000 lines of code; ~10^8 control variables.

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Sykes, R.I., C.P. Cerasoli, D.S. Henn, The representation of dynamic flow effects in a Lagrangian puff dispersion model, Journal of Hazardous Materials A:64, 223-247, 1999.

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Hazard Prediction with Nowcasting

Overview of Mesoscale Meteorological Modeling for Dispersion Applications at the Naval Research Laboratory

Science and Technology for Chem-Bio Information Systems Conference
Albuquerque, NM October 2005

Jason Nachamkin* and John Cook

Naval Research Laboratory, Monterey CA

Michael Frost, Daniel Martinez, and Gary Sprung

Computer Sciences Corporation, Monterey, CA

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Hazard Prediction with Nowcasting

- **Description:** Develop capability to use high-resolution (~1 km) COAMPS®* atmospheric forecasts as input for DoD dispersion models, and quality check the results.
- **Performers**

Jason Nachamkin[1] (PI), John Cook[1], Mike Frost[2], Daniel Martinez[2], and Gary Sprung[2]

[1]Naval Research Laboratory [2]Computer Sciences Corporation

*COAMPS® is a registered trademark of the Naval Research Laboratory

Hazard Prediction with Nowcasting

- 2005 Objectives:
  - Develop high-resolution (~1 km hz grid spacing) atmospheric prediction capability to support DoD WMD forecasts.
  - Incorporate predicted battle space environment variables into improved chemical/biological dispersion models (JEM, HPAC, VLSTRACK).
  - Demonstrate the quality of the atmospheric and dispersion forecasts.
- 2006-07 Objectives:
  - Develop surface analysis package for COAMPS®/NAVDAS
  - Boundary layer/surface flux parameterizations

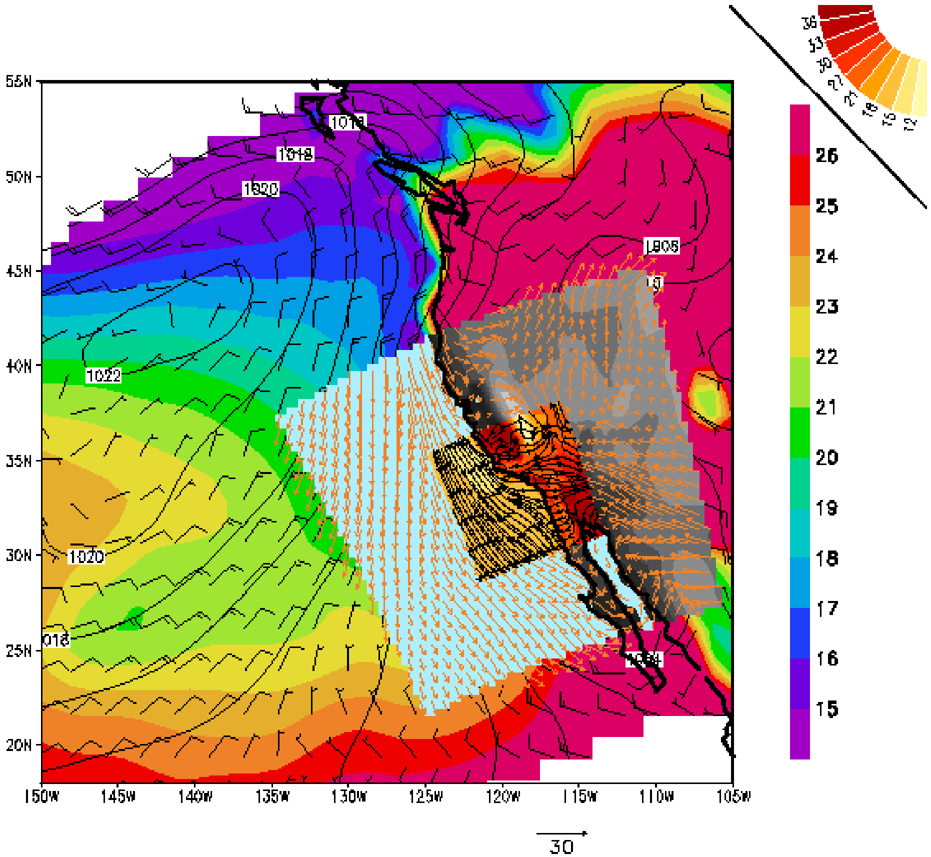
Hazard Prediction with Nowcasting

2005 Milestones:

- Generate COAMPS® forecasts for Dipole Pride 26 field project and store results in a database.
- Develop interface for JEM using HPAC as a surrogate.
- Generate HPAC, VLSTRACK, and JEM forecasts using the COAMPS® forecasts.
- Demonstrate the quality of the JEM forecasts in comparison with the HPAC and VLSTRACK forecasts using the full suite of atmospheric forecast fields.

Hazard Prediction with Nowcasting

COAMPS-OS® is a globally re-locatable atmospheric data assimilation and forecast system



- Highly automated, limited area, multi-scale, local control
- NCODA/NAVDAS Ocean/Atmosphere analyses
- Nonhydrostatic Mesoscale forecasts generated from the COAMPS® model using MPI for scalability
- Automatically transforms output into dynamic web graphics
- Digital data in TEDS and flat files for interface to other applications
- Web-based interface

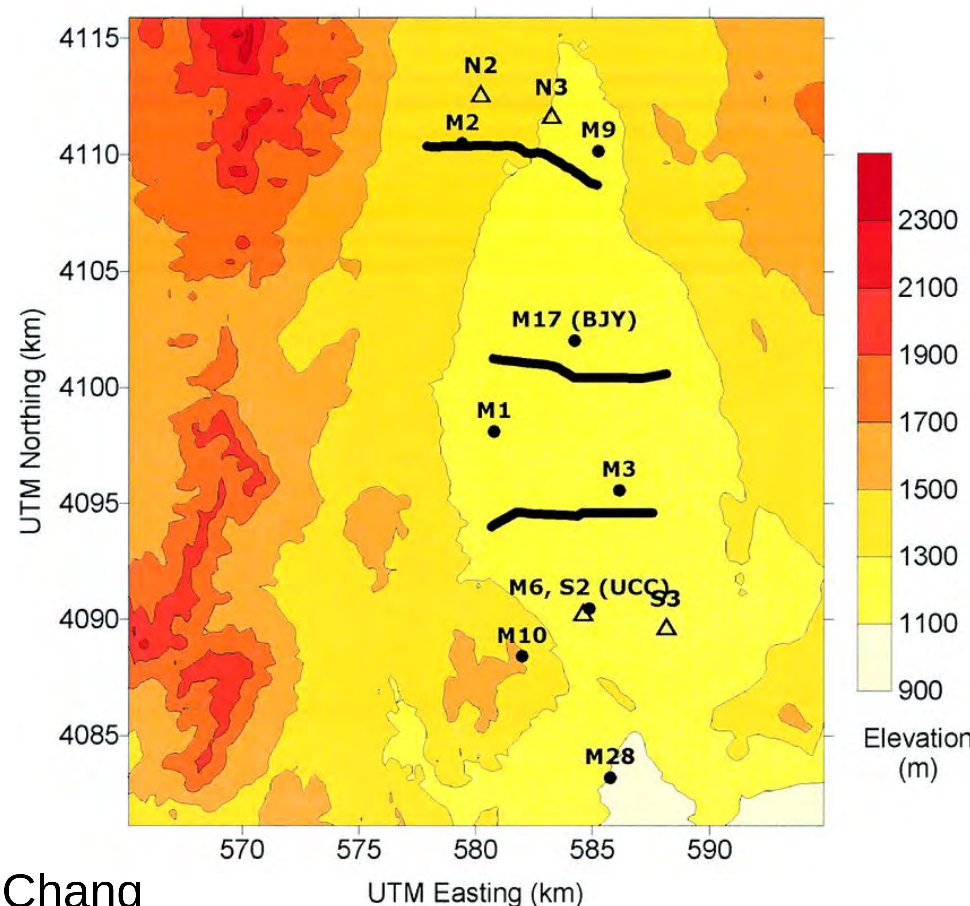
*COAMPS-OS® is a registered trademark of the Naval Research Laboratory

Hazard Prediction with Nowcasting

Dipole Pride 26:

- November 1996
- 17 field trials over 14 days
- Observed plumes (SF_6) tracked over mesoscale (~30 km) areas
- 15-minute contaminant measurements from 3 sampling lines
- 15-minute surface observations from 25 MEDA stations
- 3-hourly upper air measurements
- Chang et al. 2003 Study

Yucca Flat



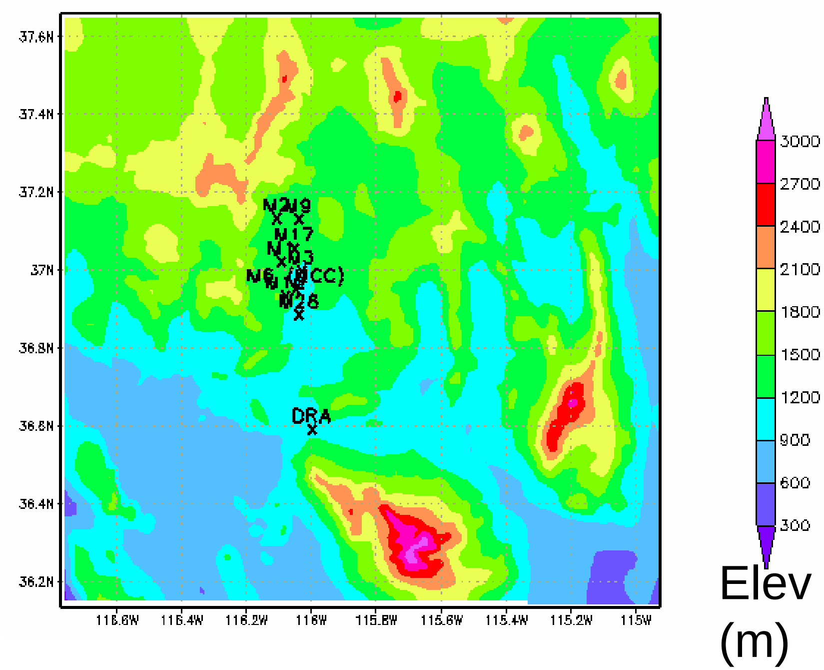
From Chang et al. 2003

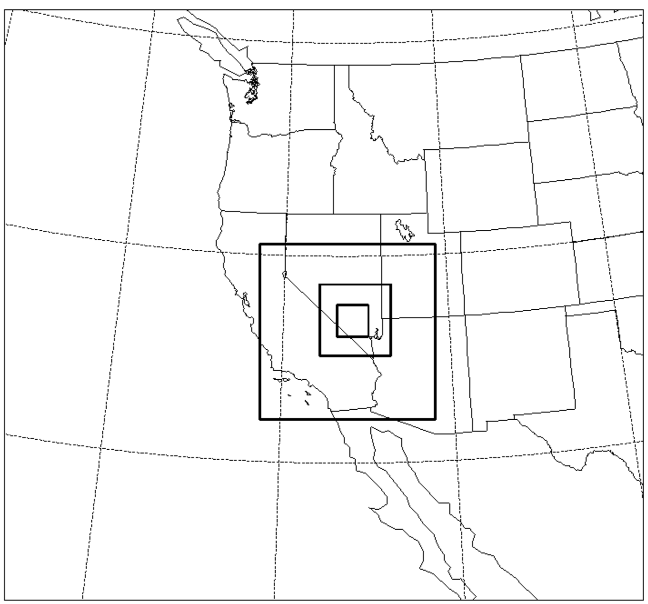
Hazard Prediction with Nowcasting

COAMPS® simulations:

- 18-hour forecasts
- 60 vertical levels, 15 layers within lowest 1500 m
- Nonhydrostatic, full physics suite
- 6-hour NOGAPS boundary forcing

Nest 4 Topography





Four nests: 27 km, 9 km, 3 km, 1 km

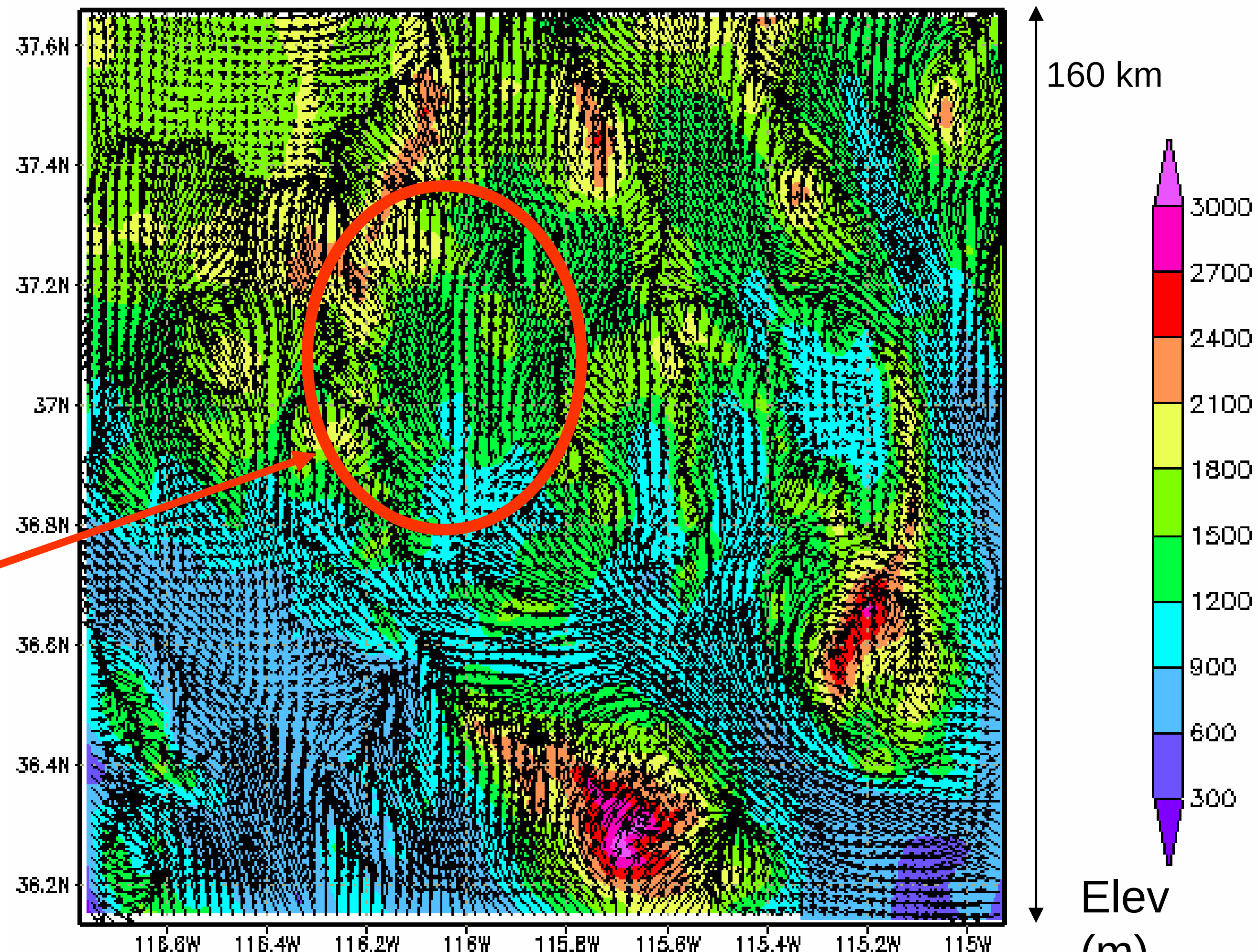
Hazard Prediction with Nowcasting

COAMPS®
simulations:

- Evolving 3-D flow
- Highly variable
- Mesoscale terrain-forced circulations
- Validation required

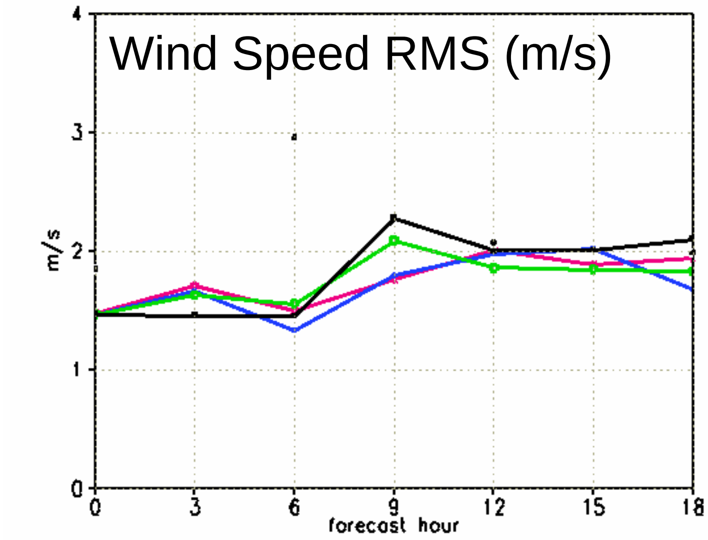
Dipole Pride 26

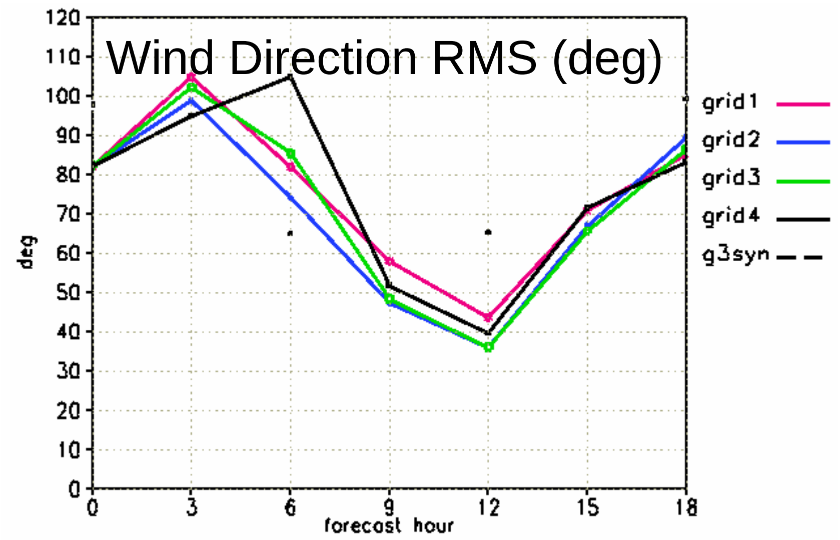
Nest 4, 10m wind and Topography



12-hr FCST valid 1600 PST 21 Nov 1996 7 m/s

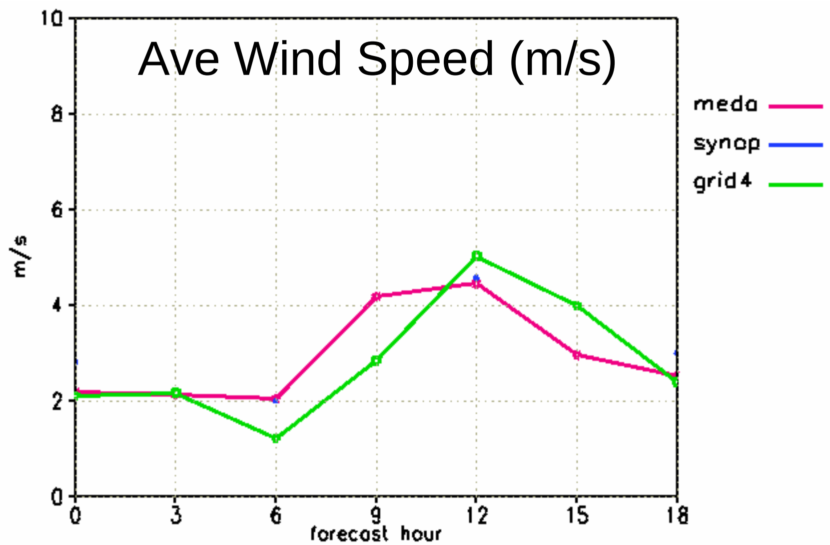
Hazard Prediction with Nowcasting



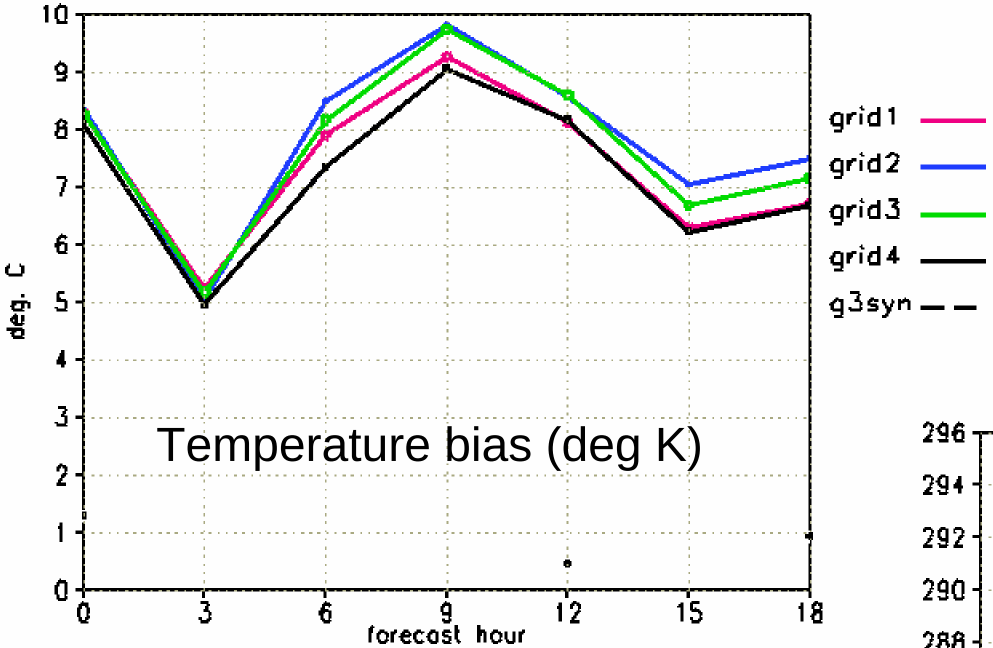


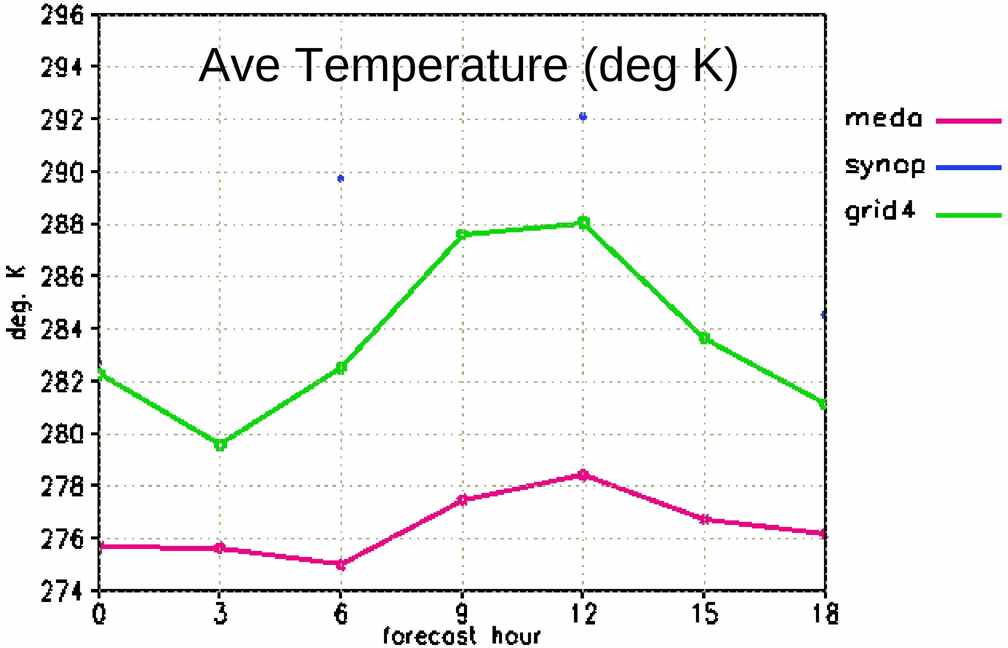
COAMPS® 10 m Statistics:

- Sanity check against MEDA and SYNOP stations
- Direction errors decrease with increasing wind speed
- Little dependence on grid spacing



Hazard Prediction with Nowcasting



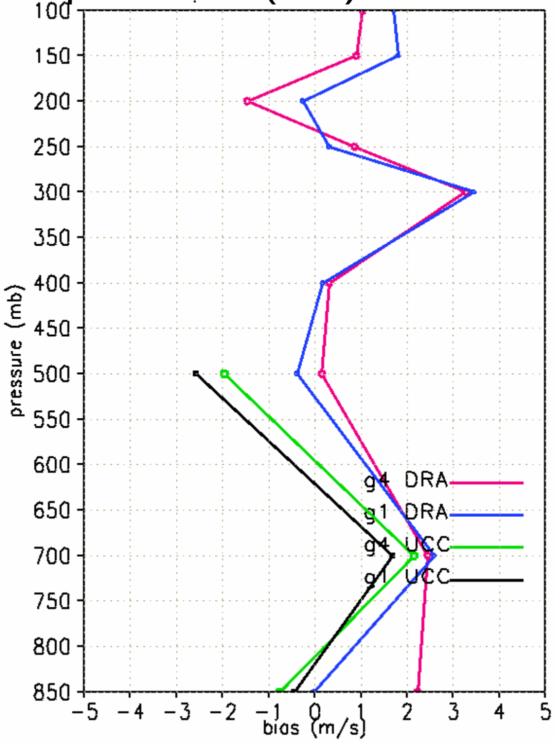


10 m Temperature Statistics:

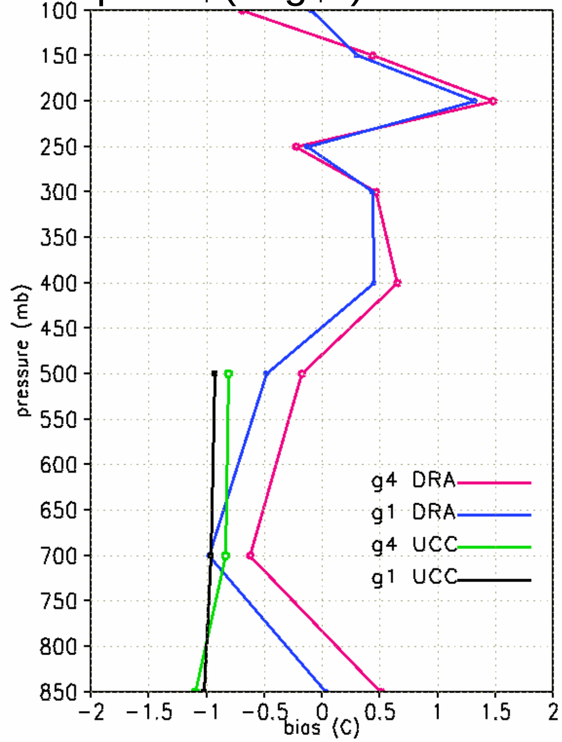
- Intercomparison between forecast, MEDA and SYNOP stations reveals MEDA station error
- COAMPS® analysis serves as cross reference check

Hazard Prediction with Nowcasting

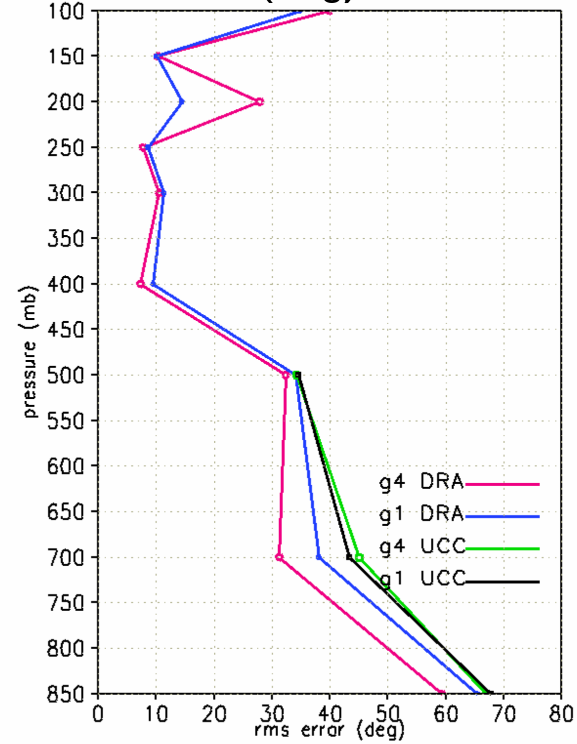
Speed bias (m/s) 12 hr FCST



Temp bias (deg C) 12 hr FCST



Dir RMS (deg) 12 hr FCST



Upper Air Statistics:

- Direction errors decrease with height
- Temperature biases less than 1 deg. C
- Little dependence on grid spacing

Hazard Prediction with Nowcasting

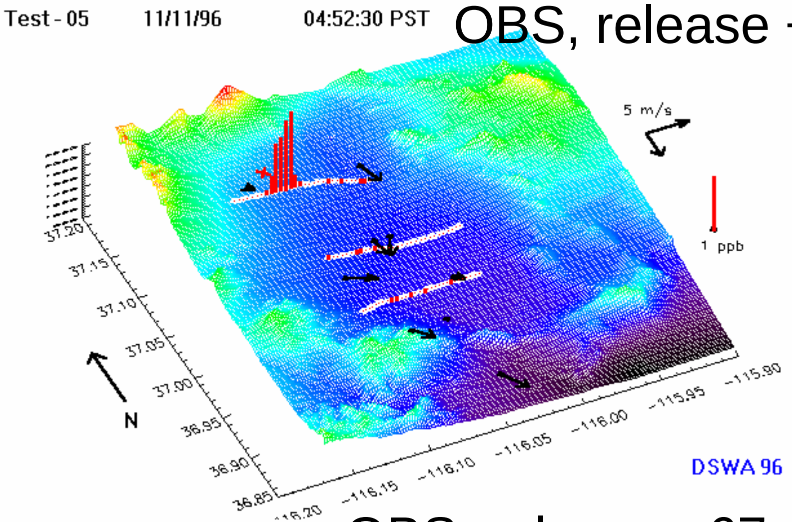
COAMPS-OS® Interface for JEM:

- HPAC interface created as surrogate for JEM
- Provided COAMPS® grib files to Kyle Dedrick (ATK-MRC/DTRA) for import into the MDS.
- Standard (30-level) and high-resolution (60-level)
- Upgrading VLSTRACK capabilities to accept 60-level forecast input
- COAMPS-OS® will be ready for JEM

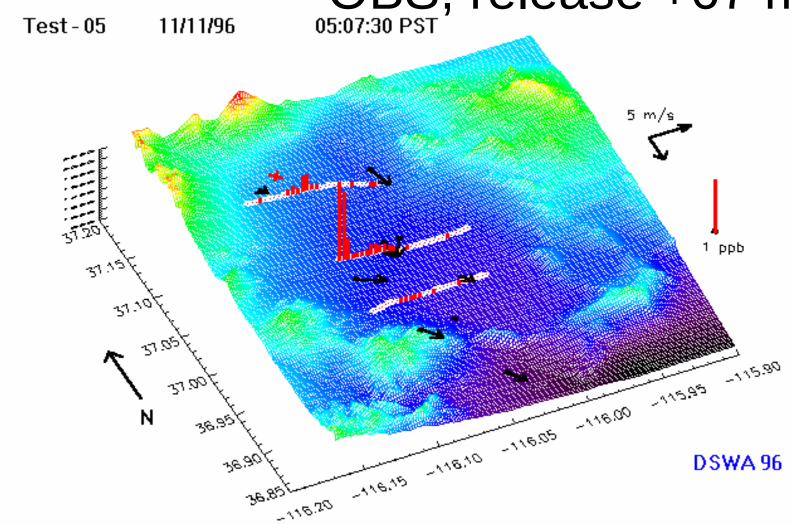
Hazard Prediction with Nowcasting

11 November 1996 test case

OBS, release +52 min

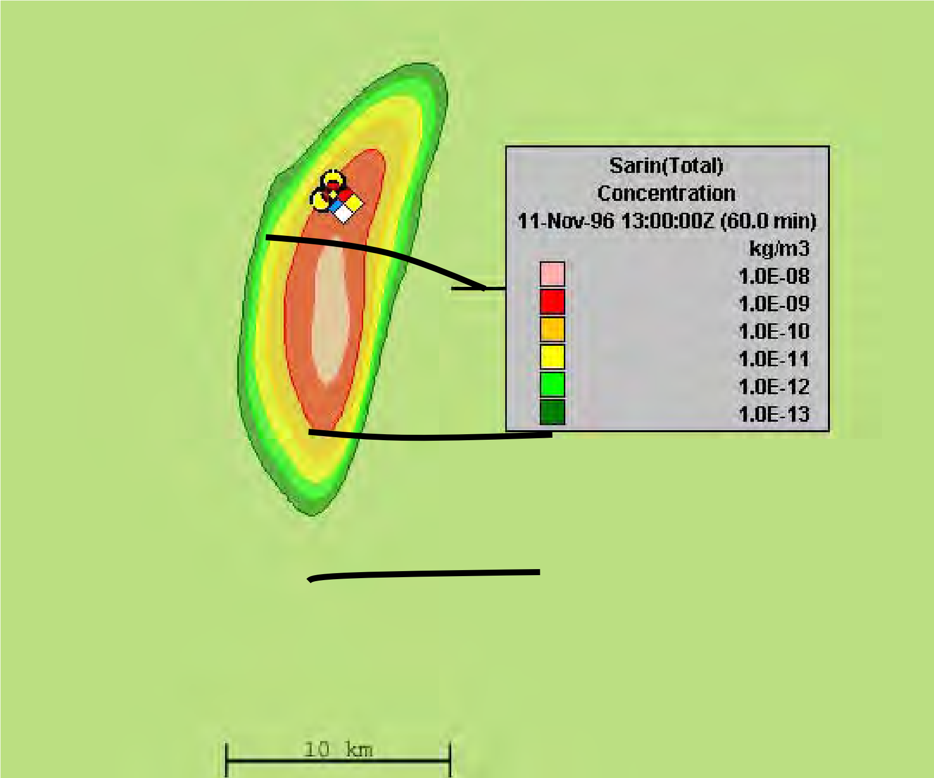


OBS, release +67 min



Ongoing tests show good qualitative agreement between obs and COAMPS-driven HPAC.

HPAC 1-hr FCST



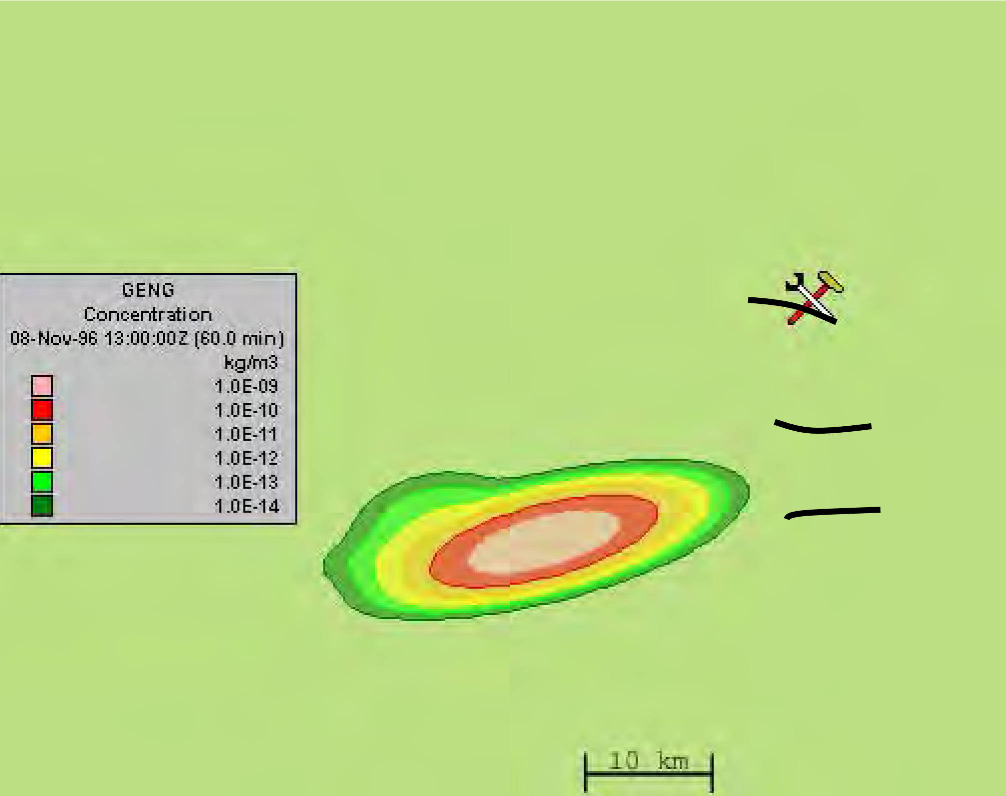
Hazard Prediction with Nowcasting

8 November 1996 test case

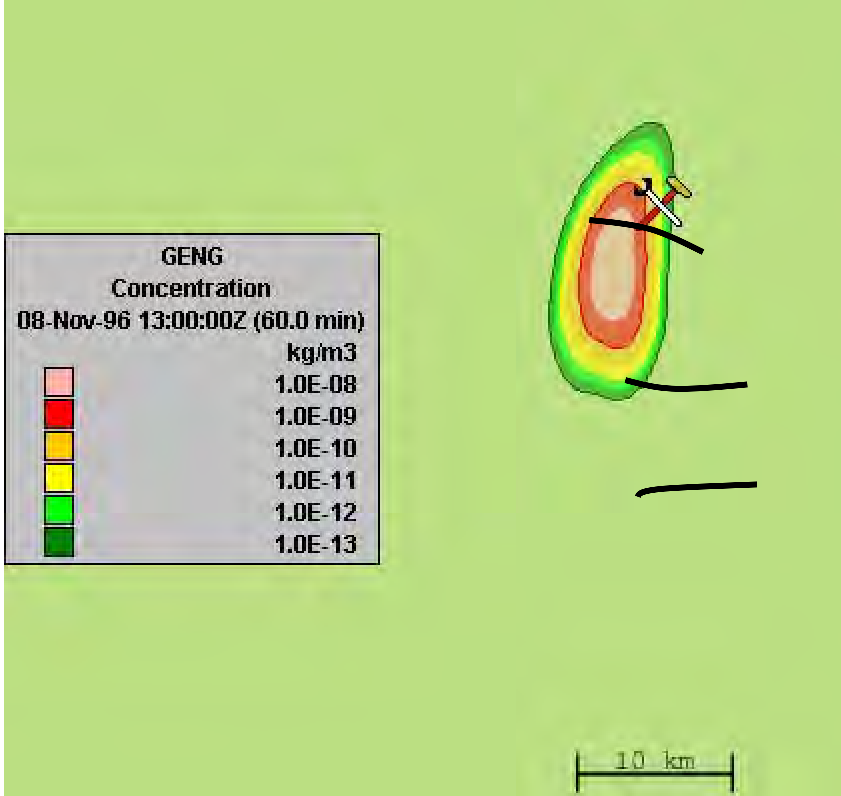
Contaminant trajectories are strongly dependent on nest resolution

HPAC 1-hr FCSTS Valid 13 UTC 8 November 1996

27 km COAMPS Forcing



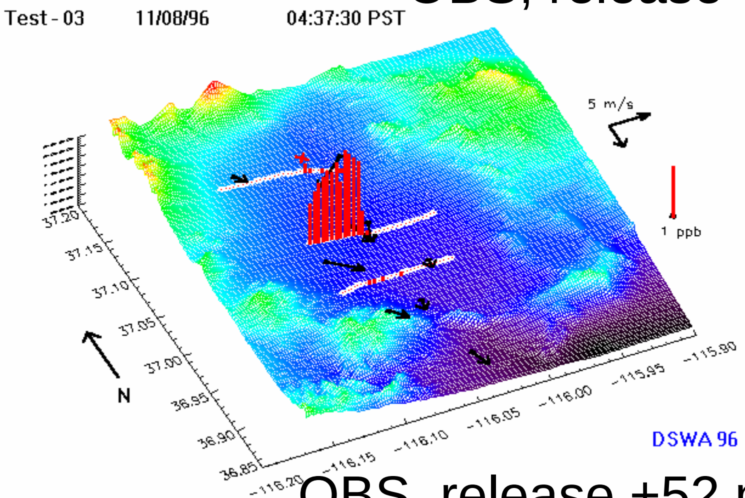
1 km COAMPS Forcing



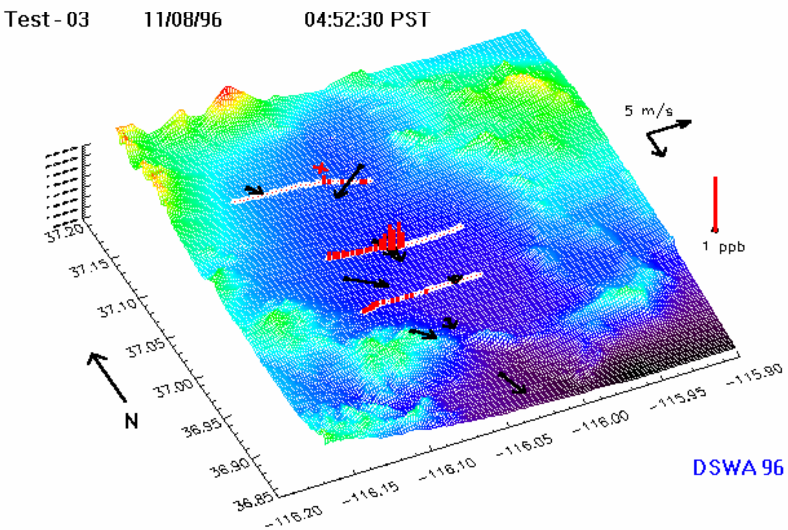
Hazard Prediction with Nowcasting

8 November 1996 test case

OBS, release +37 min

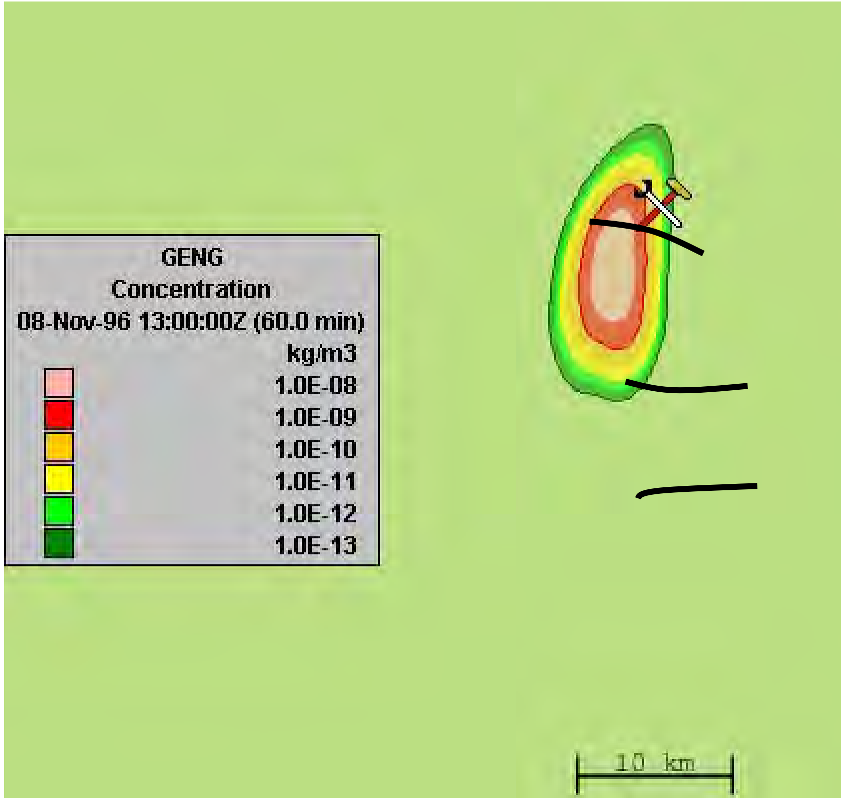


OBS, release +52 min



1km forcing shows better qualitative agreement

1 km COAMPS Forcing

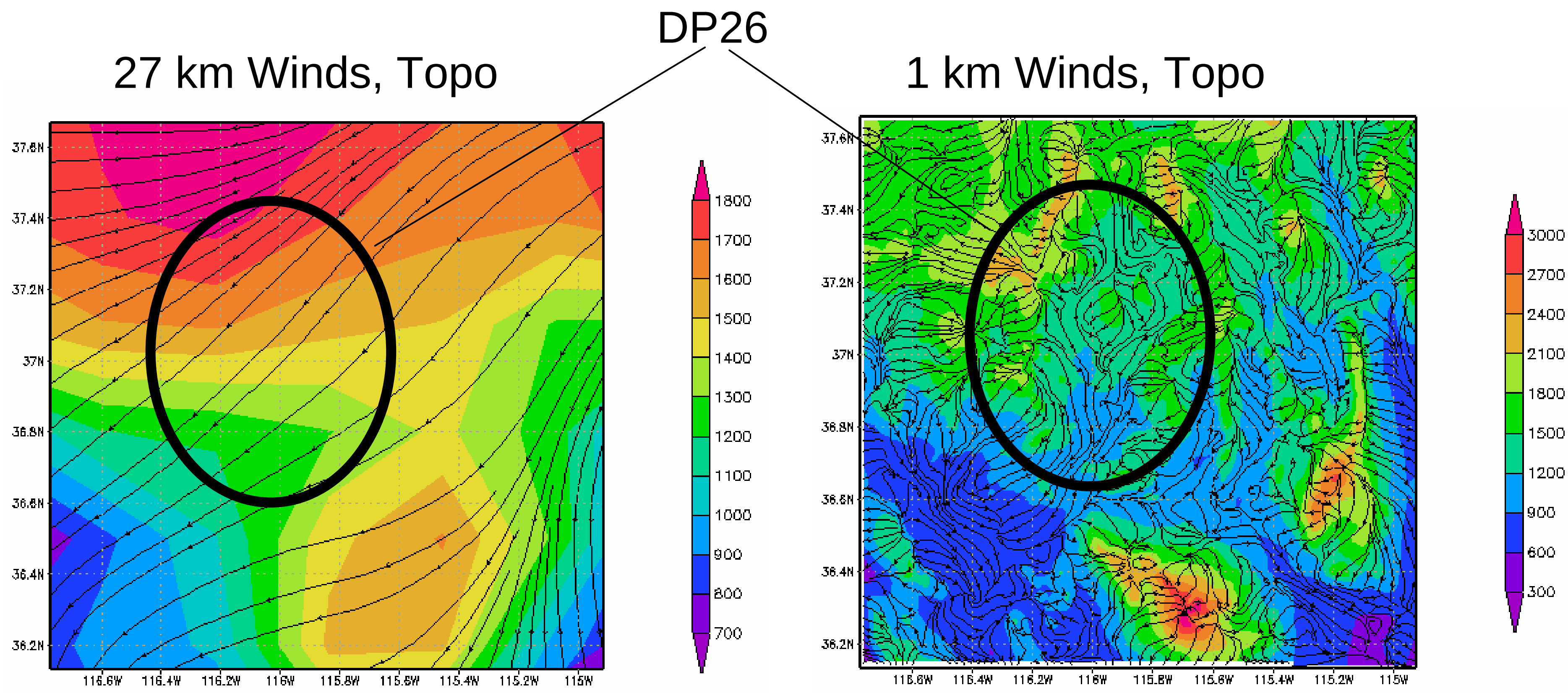


Hazard Prediction with Nowcasting

8 November 1996 test case

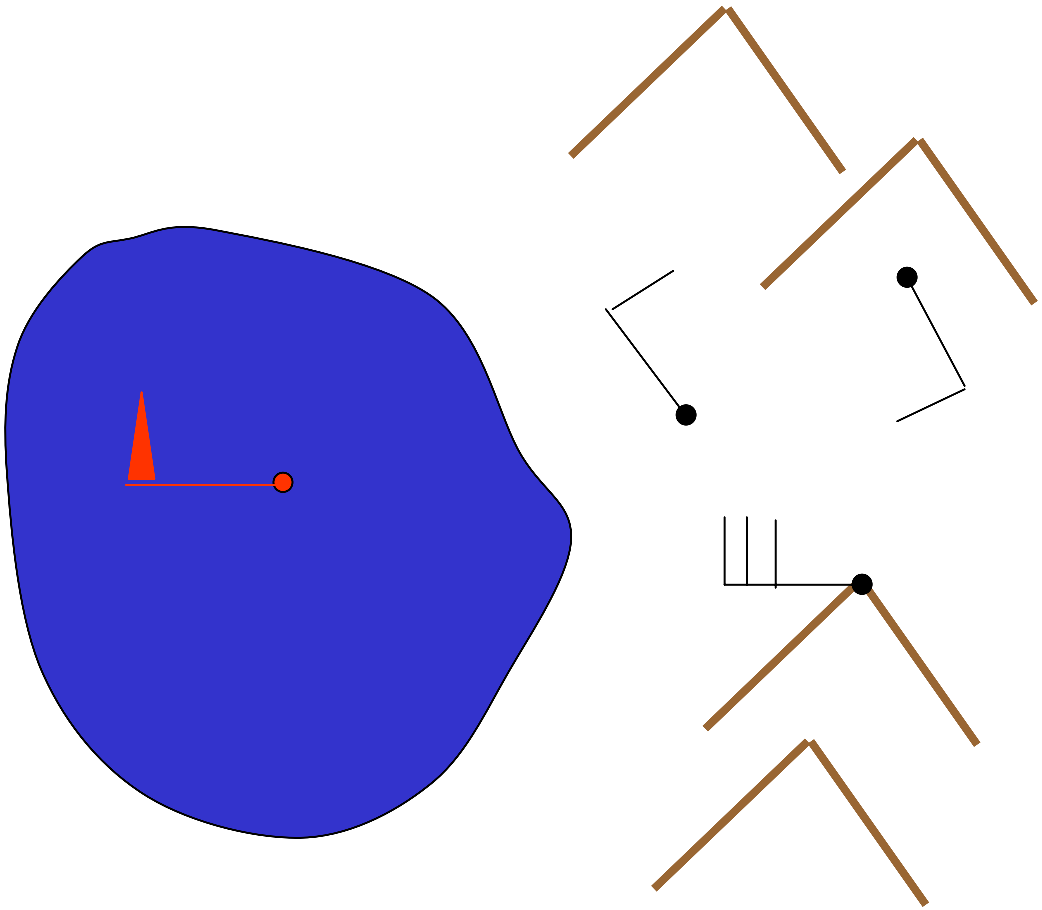
1km forcing shows more realistic flow structure

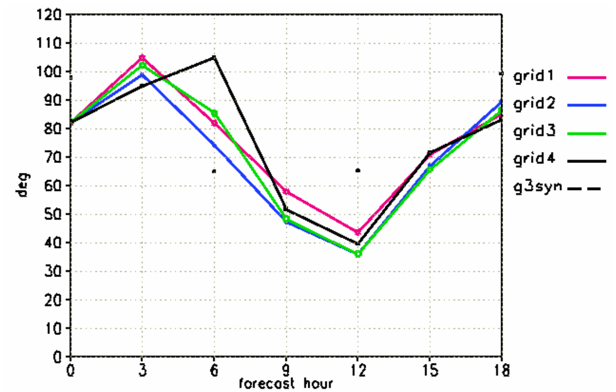
COAMPS® 12-hr FCSTS Valid 12 UTC 8 November



Hazard Prediction with Nowcasting

High-Resolution Lower Tropospheric Data Assimilation





Want to reduce error while maintaining physically consistent 3-D structure.

Hazard Prediction with Nowcasting

Northern SF Bay Landsat Image

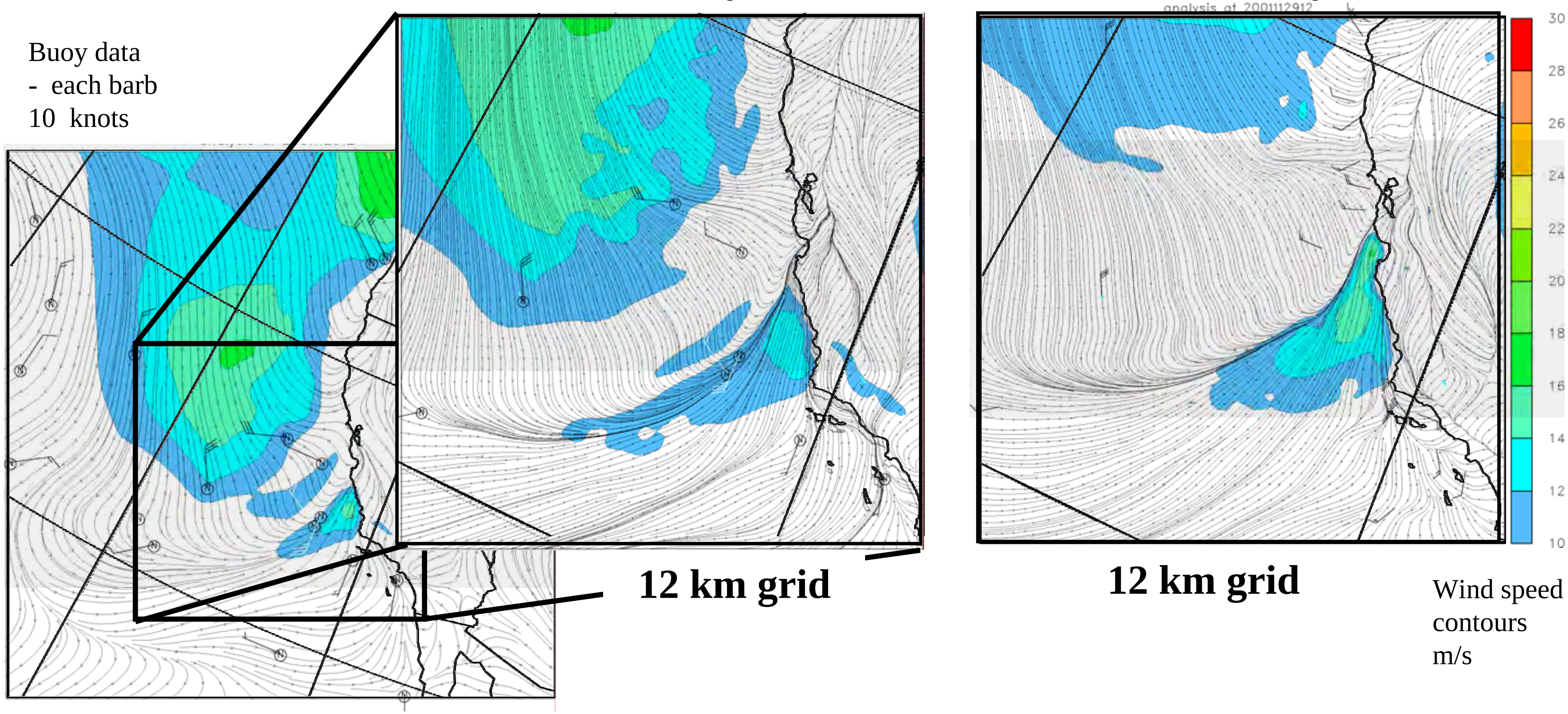
Hazard Prediction with Nowcasting

NAVDAS

- **NAVDAS is a modern 3-D variational analysis for COAMPS®**
  - Pre-Ops testing at FNMOC prior to operations (Oct-Dec 2005).
  - Much of the code shared with global version for NOGAPS
- **NAVDAS uses the actual pressure level of each observation in analysis**
  - Uses all mandatory and significant level observations from soundings, aircraft data, satellite feature-rack winds, satellite temperature retrievals; MVOI only mandatory pressure levels
  - Applies correct surface pressure for surface marine observations; MVOI assigns surface data to 1000 mb level for analysis.
  - Currently land surface data at elevs above 50m not used.
- **NAVDAS can define background covariance in different vertical coordinates - pressure or potential temperature.**
- **NAVDAS has improved upper-air and surface marine wind and temperature analyses.**

Hazard Prediction with Nowcasting

10 m wind analysis; NAVDAS vs. MVOI valid 2001112912



- **NAVDAS uses a single multi-grid analysis (with actual pressure levels)**
- **NAVDAS analysis more consistent between grids and better fit to buoy wind observations**

NAVDAS Surface Data Analysis Plans

- **Independent 3-D lower tropospheric analysis in terrain following coordinates**
  - Use surface observations of temperature, humidity and wind over land.
  - Use satellite temperature and moisture retrievals, satellite skin temperature retrievals produced by global NAVDAS 1dvar radiance code over land.
  - Currently such surface data at elevations above 50m over land are not used by NAVDAS.
- **Hourly surface analyses**
  - Use COAMPS forecast as background at asynoptic hours and update NAVDAS analyses at synoptic hours
- **Native COAMPS sigma-height coordinate defines boundary layer background correlation function**
  - Modified to account for differences in terrain and potential temperature
- **Full 3-D boundary layer structure at high resolution**

Hazard Prediction with Nowcasting

Conclusions:

- Gridded COAMPS forecast fields can be used to produce useful contaminant forecasts.
- High-resolution model output show improved performance in HPAC despite RMS errors.
- COAMPS® output will be ready for JEM.

Current/Future Work:

- Complete quantitative DP26 study using COAMPS® fields in VLSTRACK, HPAC and JEM.
- Improve boundary layer and surface flux parameterizations
- 3DVar data assimilation at high-resolution with high-frequency updates
- Mesoscale validation techniques specifically targeted for coastal applications

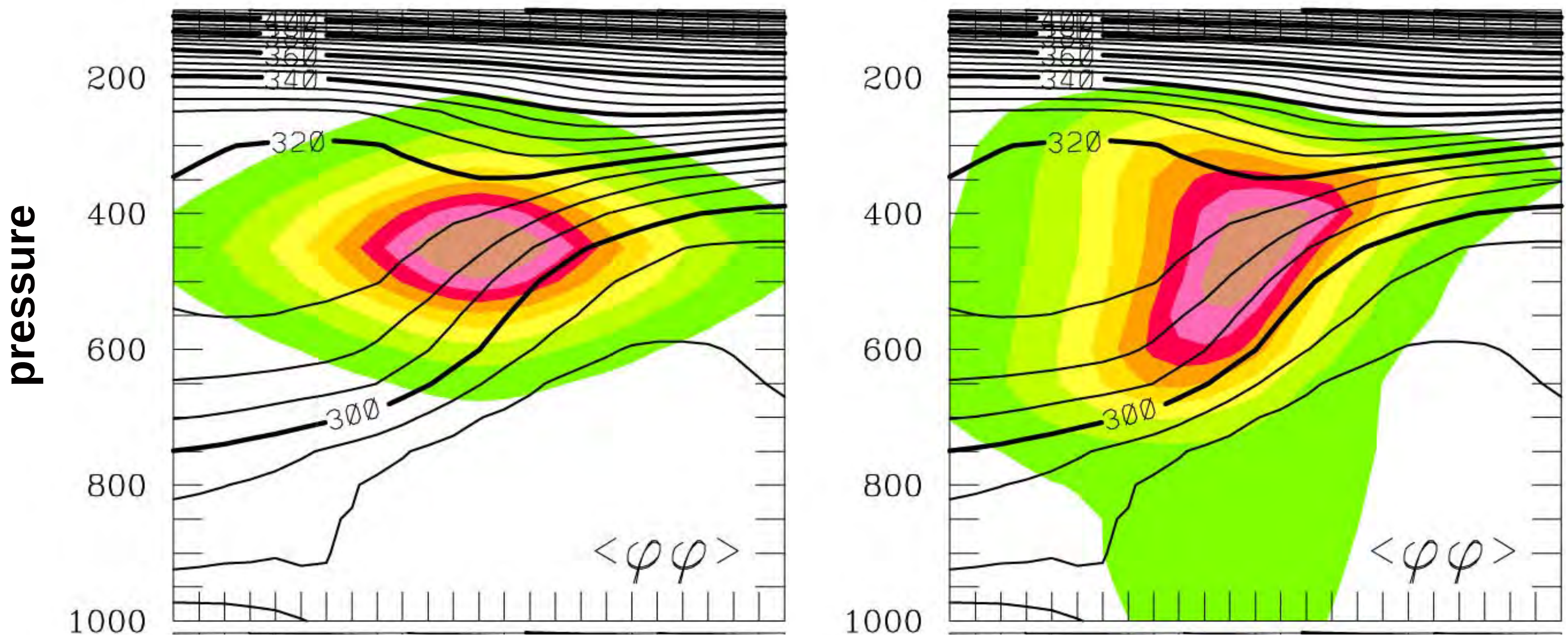
EXTRA SLIDES

Hazard Prediction with Nowcasting

Correlation Function for Background Error

Geopotential Height correlation in NAVDAS can use different vertical coordinates:

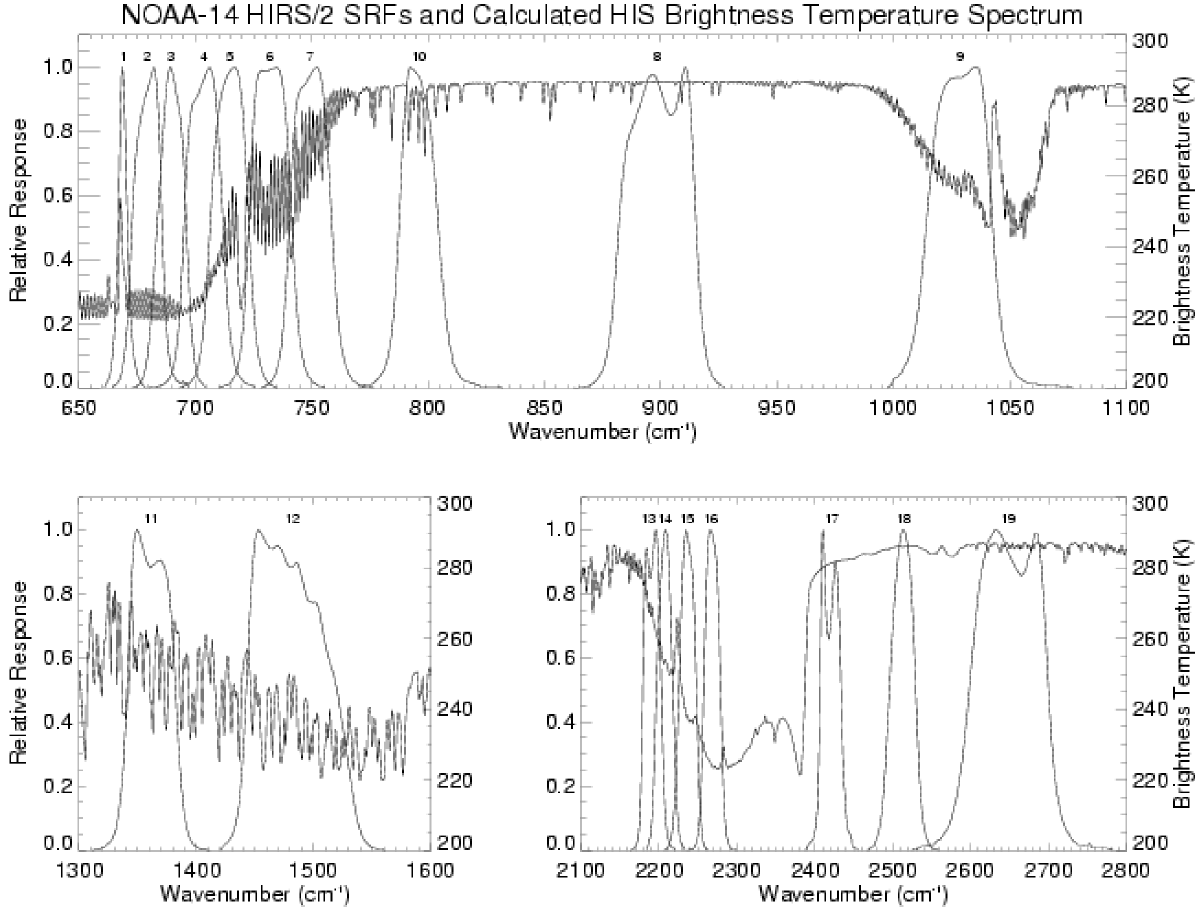
Standard pressure coordinate or Isentropic vertical coordinate

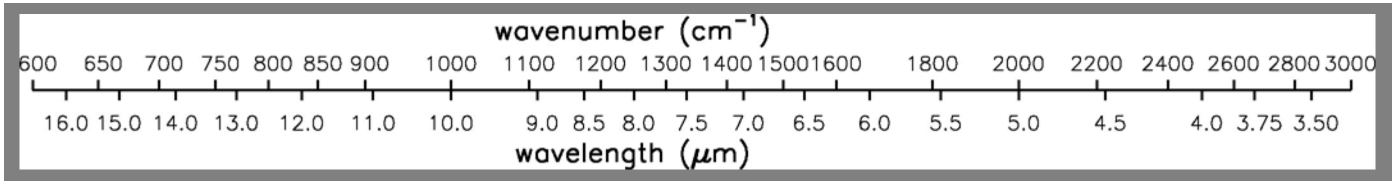


versus horizontal distance

Hazard Prediction with Nowcasting

HIRS Channel Response vs. US Std. Atmos. Emission Spectra

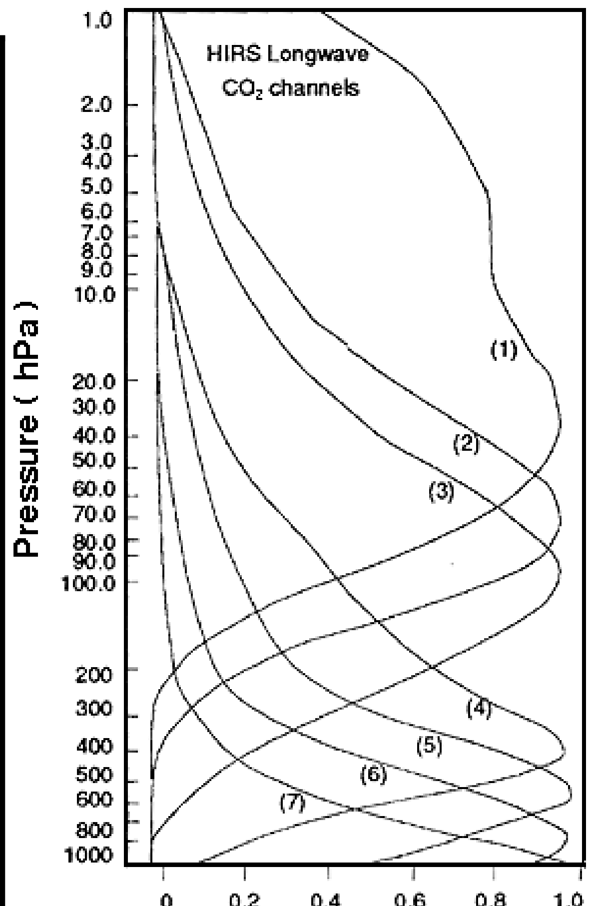


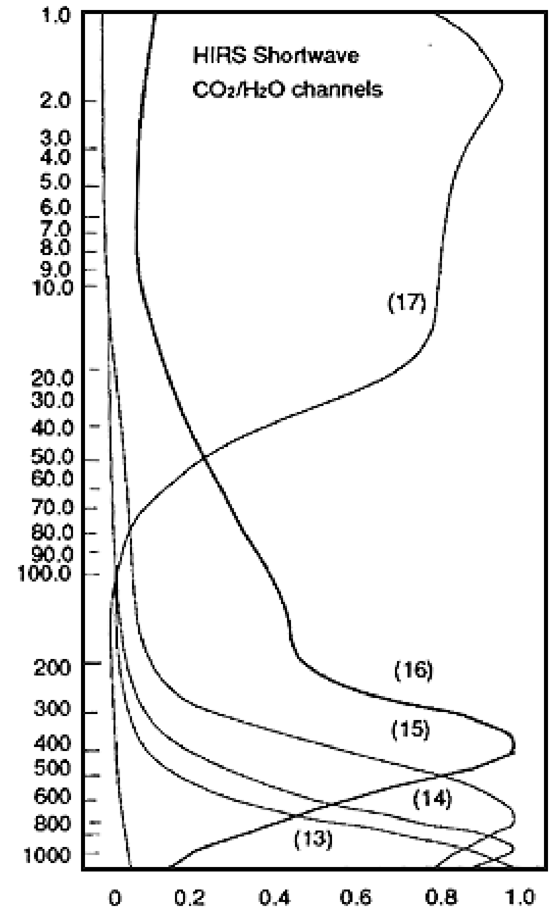


Hazard Prediction with Nowcasting

HIRS Sounding Channel Temperature Weighting Functions

Channel	Wavenumber (cm^{-1})	Wavelength (µm)
1	669	14.95
2	680	14.71
3	690	14.49
4	703	14.22
5	716	13.97
6	733	13.64
7	749	13.35
8	900	11.11
9	1030	9.71
10	802	12.47
11	1365	7.33
12	1533	6.52
13	2188	4.57
14	2210	4.52
15	2235	4.47
16	2245	4.45
17	2420	4.13
18	2515	4.00
19	2660	3.76



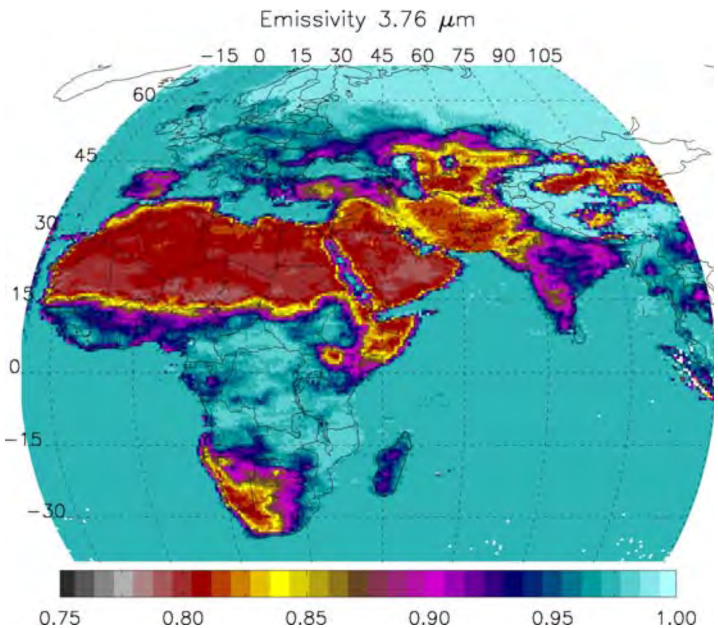


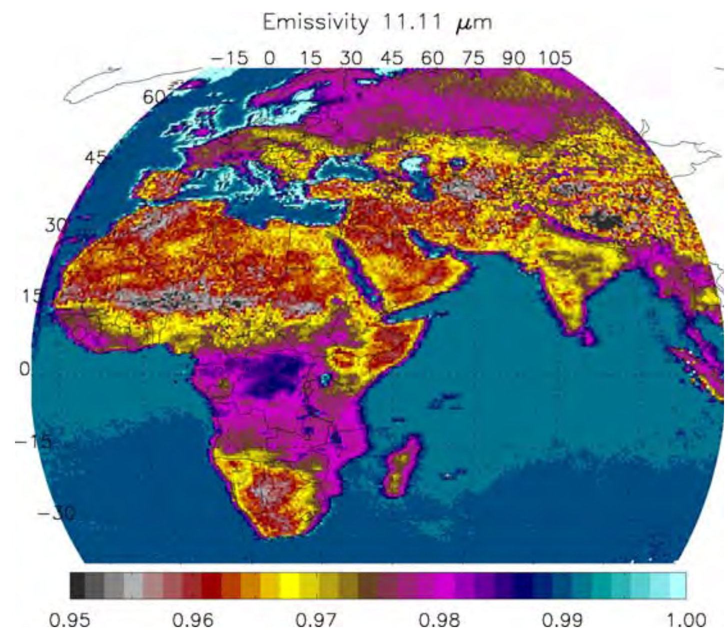
gray = water vapor

red = “window” channels

Hazard Prediction with Nowcasting

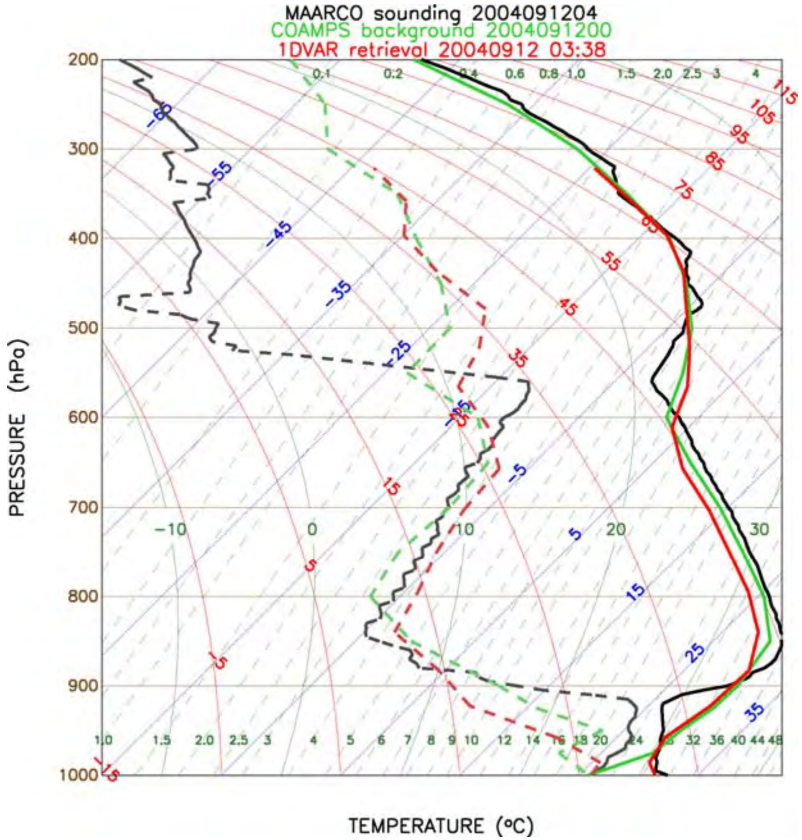
Surface Emissivity Means *(Mar/Apr 2003)*





Hazard Prediction with Nowcasting

Satellite Temperature Retrievals Show Positive Impacts in Boundary Layer *(Sep 2004)*



Chemical Agent Fate Program (CAFP)

Development of an Evaporation Model for HD on Non-Porous Surfaces

By:

Brad Dooley
California Institute of Technology
Pasadena, California

H. K. Navaz
Kettering University
Flint, Michigan

Objectives

- To develop a **simple engineering** tool that can **predict** the evaporation rate of HD on non-porous surfaces and provide information about
  - The amount of mass being evaporated and transported by the wind
  - The amount of mass being absorbed/desorbed into a porous substrate
  - The basic behavior of a drop under the outdoor conditions

Scientific Problems to Be Addressed

- Evaporation
  - Modeling sessile drop behavior
- Validation
- Generalization
  - How to generalize our efforts to enhance prediction capability by
    - ✓ A hybrid approach
    - ✓ Imposing outdoor conditions
- Linkage to porous substrate

Evaporation Module

- A module that is mostly based on first principles and provides the following information
  - Forcing function - the evaporation rate, $\dot{m}$
    - ✓ Can be modified, improved, replaced, ...
  - Topology of the droplet by solving a differential equation using the forcing function
  - Evaporated mass being added to the atmospheric air
  - Remaining mass to be transported through the porous substrate

Evaporation Module (*cont'd*) Model Development

- Forcing Function
  - Constant base area for a drop (Model A)

$$\dot{m} = 2\pi C R_s f \frac{\mu}{\quad}\left(F + C_1 \, Re^m \quad r^n\right)\ell n\left(1 + B\right) = 2\pi C R_s \frac{\mu}{\quad}\left(F + C_1 \, Re^m \quad r^n\right)\ell n\left(1 + B_M\right)$$

$$C = \frac{h}{R}$$

  - Shrinking base area for a drop (Model B)

$$\dot{m} = 2\pi R_s\left(1 - \quad \varphi\right) f \frac{\mu}{\quad}\left(F + C_1 \, Re^m \quad r^n\right)\ell n\left(1 + B\right) \quad or$$

$$\dot{m} = 2\pi R_s\left(1 - \quad \varphi\right) f \frac{\mu}{\quad}\left(F + C_1 \, Re^m \quad r^n\right)\ell n\left(1 + B_M\right)$$

Evaporation Module (*cont'd*)
Model Development

- Interaction among drops – Group Theory

  - Model 1: $G_{evap} = \dfrac{1}{1 + G_c}$ with $G_c = \dfrac{C\left(F + C_1 \quad {}^{m} \quad {}^{n}\right) \quad N^{q}\left(\dfrac{r}{\lambda}\right)}{\quad}$

Where *C* and *q* can be determined experimentally. *C=3 and q=2/3*

  - Model 2:

$$G_c = \sum_{n=0}^{\infty} \frac{(-1)^n \qquad \eta_0}{\left[(n+1)\eta_0\right]}$$

$$\textit{Where} \quad \eta_0 = \quad {}^{-1}\left(\frac{\lambda}{R}\right) \quad \textit{and} \quad 2\lambda \textit{ represents the distance between two drops}$$

$$\lambda = \frac{1}{2N^{p}}$$

where N is the number of drops and $p = 1/3$

$$G_{evap} = \begin{cases} G_c^{q} & \textit{for } N \geq n \\ \dfrac{1}{q} G_c^{q} & \textit{for } N < n \end{cases}$$

Evaporation Module (*cont'd*) Model Development

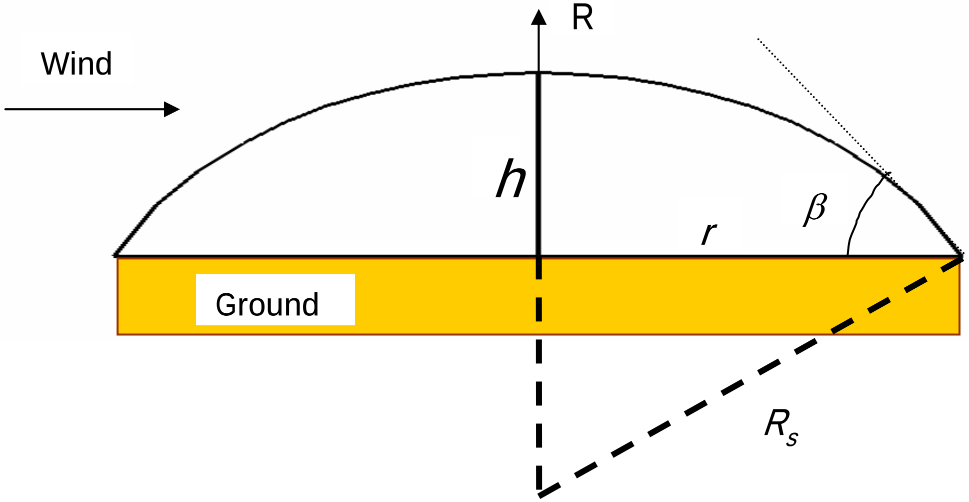
- ($\dot{m}$ is a function of time also)
- Model A

$$\frac{dh}{dt} = \frac{-\dot{m}}{\pi \rho_\ell h^2 \left(\frac{3}{C} - 1 \right)}$$

$h/R = C$

- Model B

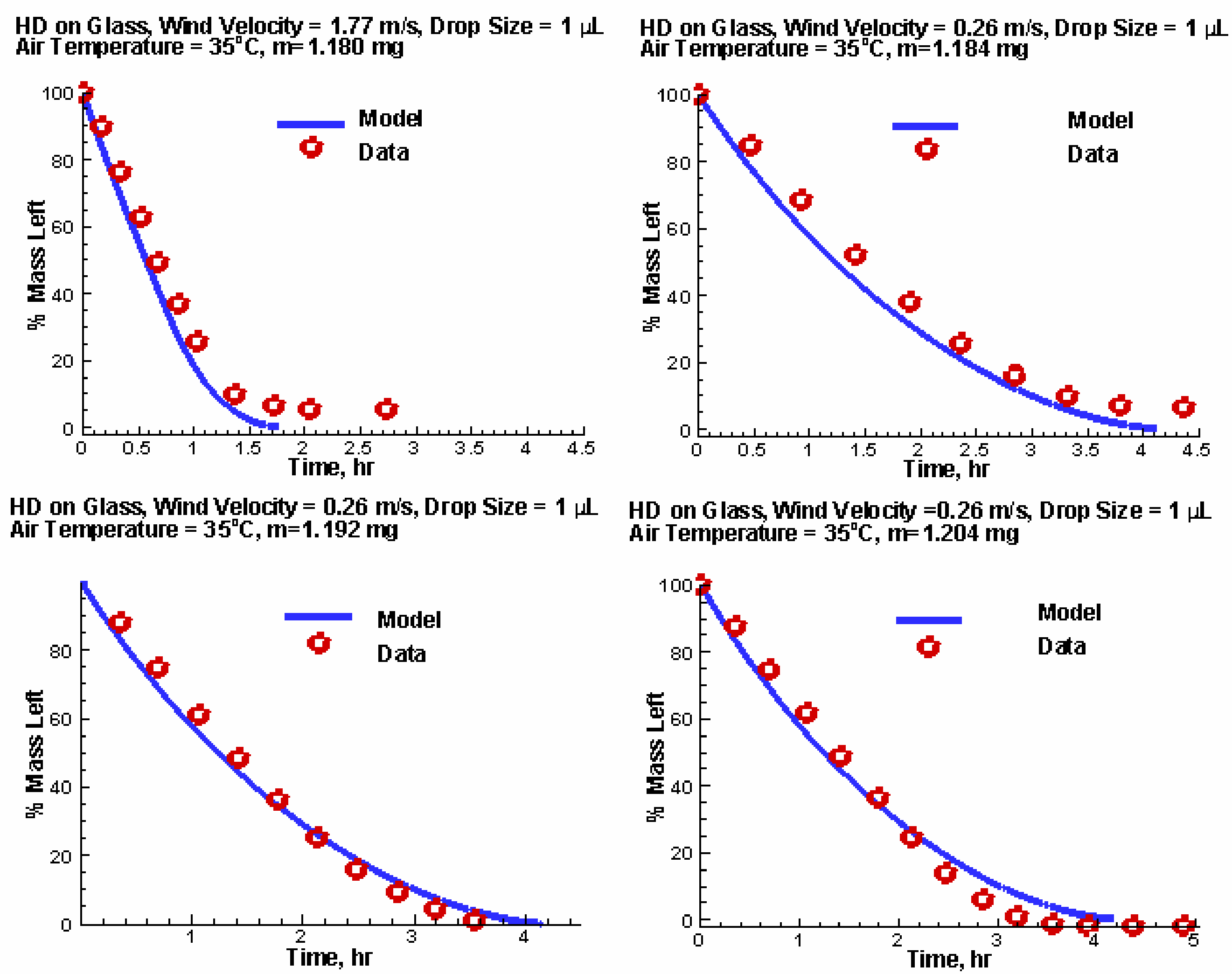
$$\frac{dh}{dt} = \frac{-\dot{m}}{\rho_\ell \frac{\pi}{2} \left(r^2 + h^2 \right)}$$



Evaporation Module (*cont'd*) How to Predict Other Scenarios?

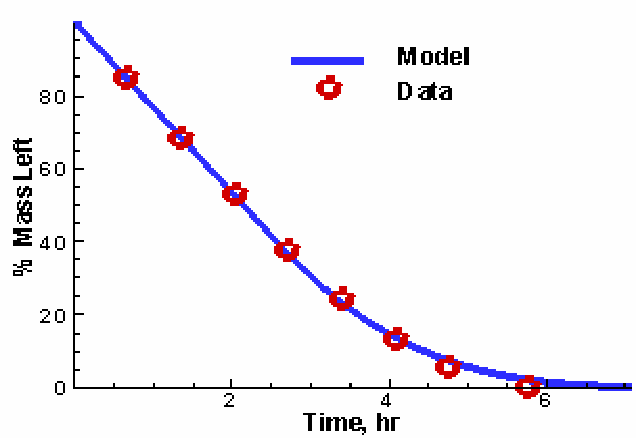
- Validate Model
- Create a matrix for the entire possible domain of operation
- Fill the matrix using the analytical model
- Use neural network curve-fit
- Create a simple engineering equation for application

Evaporation Module (*cont'd*) Validation

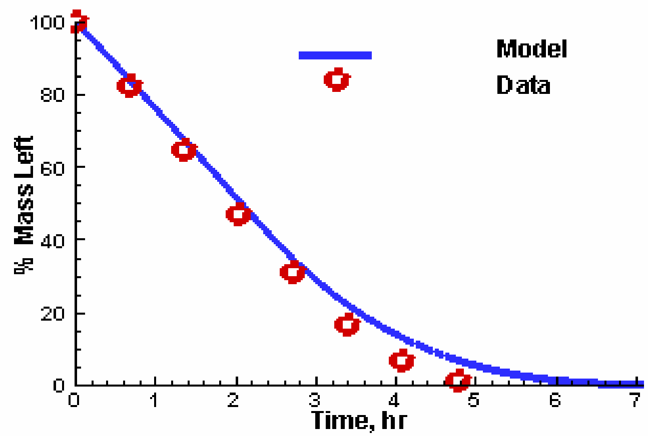


Evaporation Module (*cont'd*)
HD on Non-Porous Surface

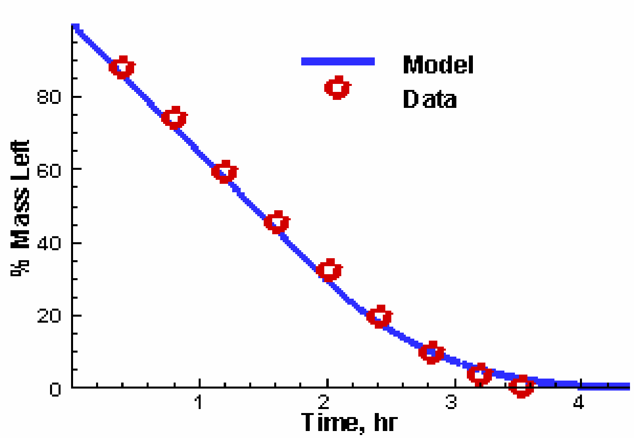
HD on Glass, Wind Velocity = 3.66 m/s, Drop Size = 1 μL
Air Temperature = 15°C, m=1.200mg



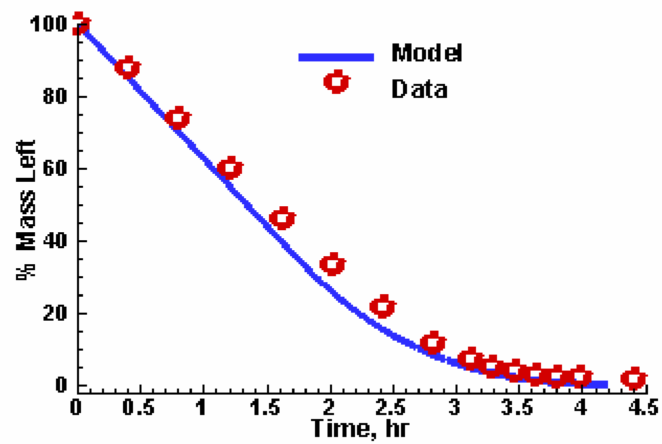
HD on Glass, Wind Velocity = 3.66 m/s, Drop Size = 1 μL
Air Temperature = 15°C, m=1.264 mg



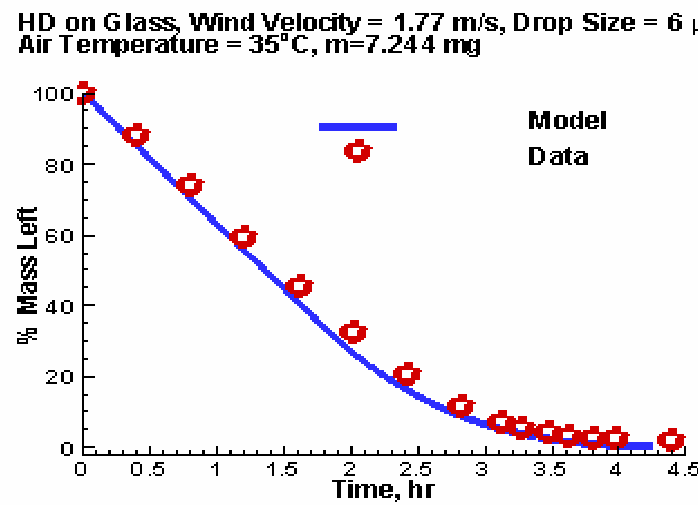
HD on Glass, Wind Velocity = 1.77 m/s, Drop Size = 6 μL
Air Temperature = 35°C, m=6.884 mg

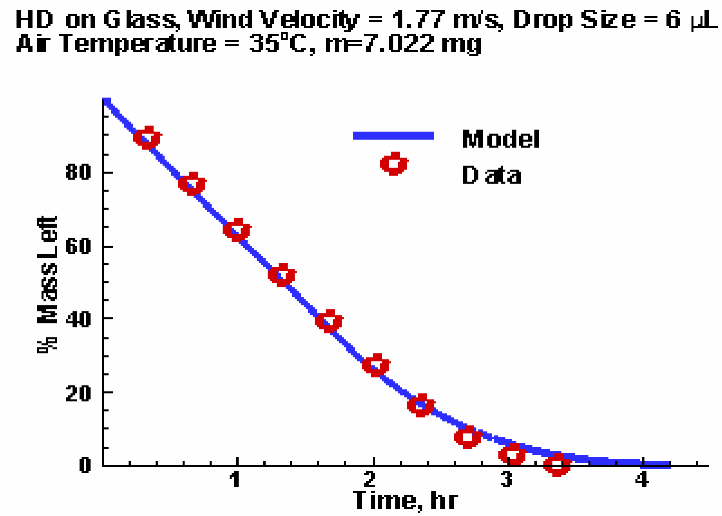


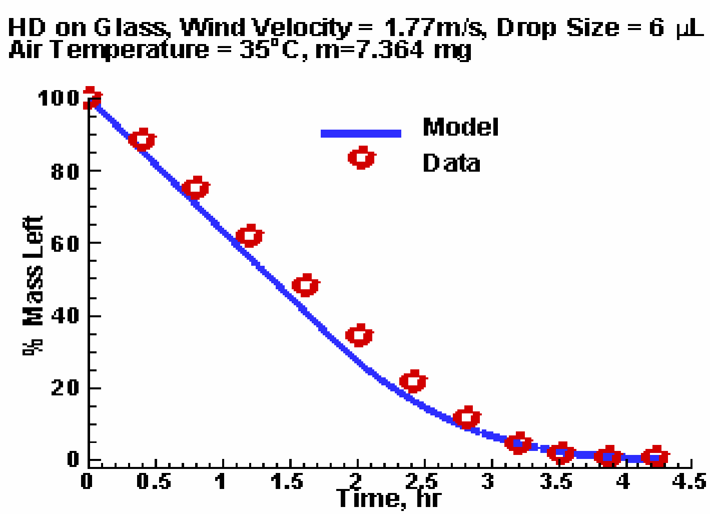
HD on Glass, Wind Velocity = 1.77 m/s, Drop Size = 6 μL
Air Temperature = 35°C, m=7.000mg

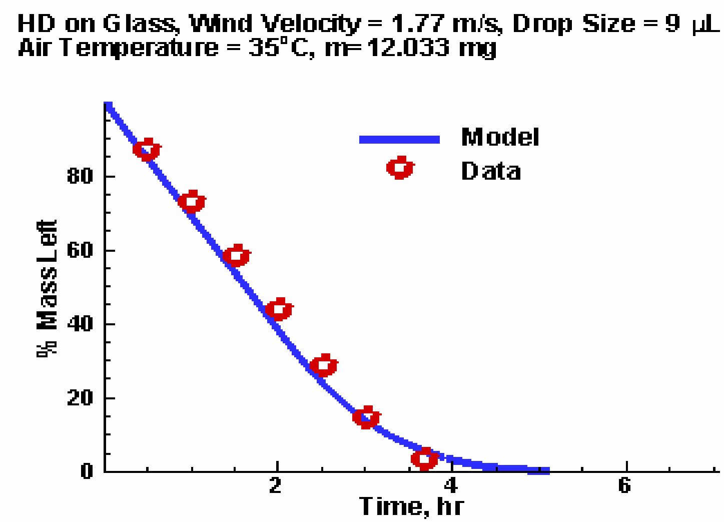


Evaporation Module (*cont'd*)
HD on Non-Porous Surface



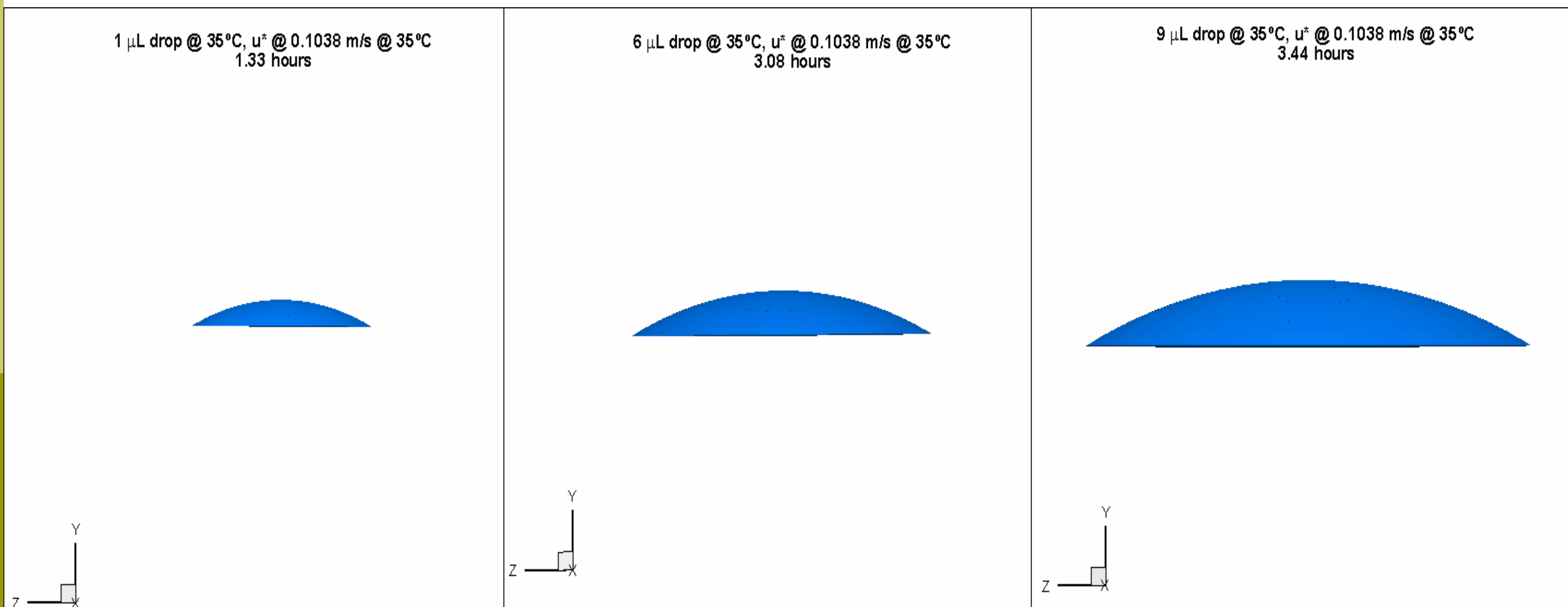






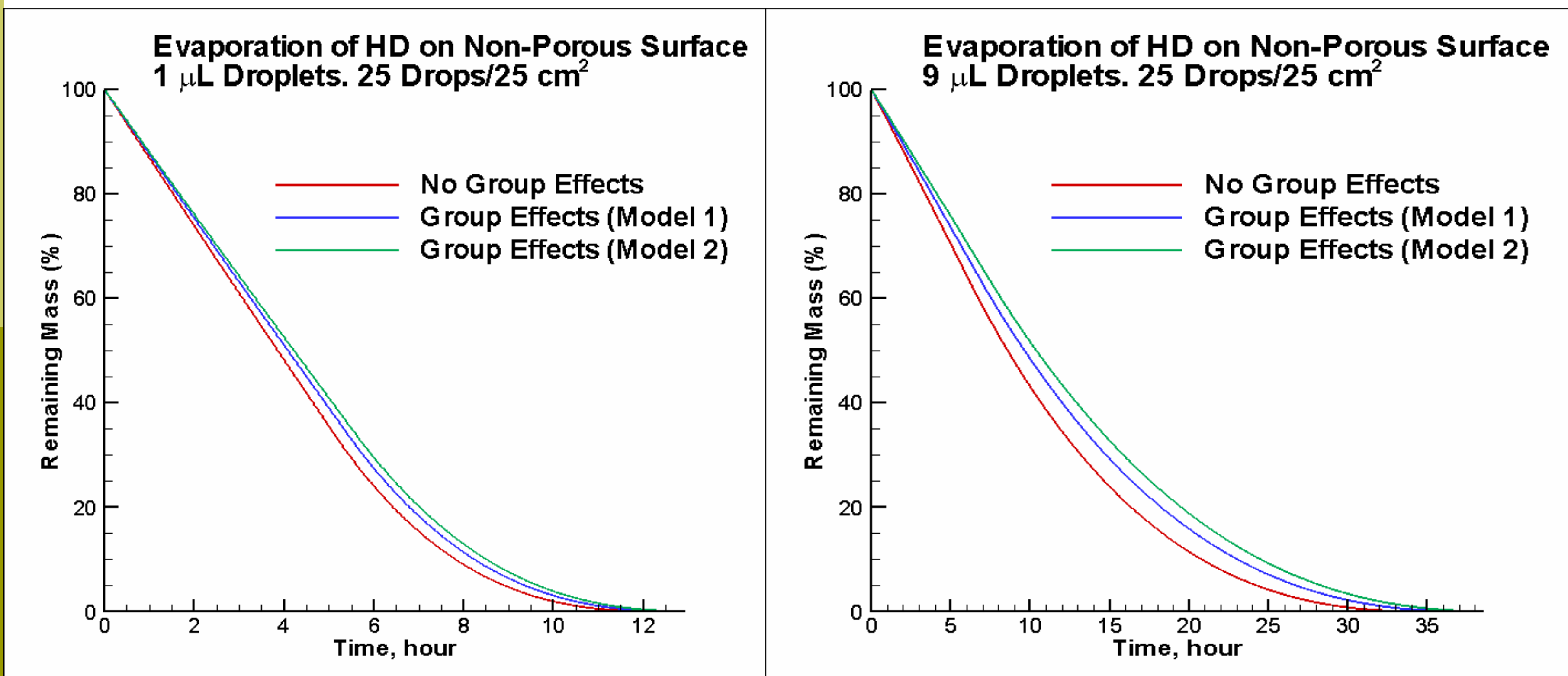
Evaporation Module (*cont'd*) - HD on Non-Porous Surface - *Droplet Topology*

- Sample animated droplet topology



Evaporation Module (*cont'd*) HD on a Non-Porous Surface – *Group Theory*

- There are two group models embedded in the code
  - Negligible for small sparse drops
  - More significant for larger and denser drops



Evaporation Module (*cont'd*) Model Generalization

			C																								
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
			T_{air}=15°C					T_{air}=25°C					T_{air}=35°C					T_{air}=50°C					T_{air}=55°C				
			T_{drop} (°C), mean value					T_{drop} (°C), mean value					T_{drop} (°C), mean value					T_{drop} (°C), mean value					T_{drop} (°C), mean value				
		u*(m/s)	17	25	35	50	55	17	25	35	50	55	17	25	35	50	55	17	25	35	50	55	17	25	35	50	55
Droplet Volume= 1μL	Number of drops per 1m²= 3600	0.0285																									
		0.1038																									
		0.1796																									
		0.1534																									
	Number of drops per 1m²= 6400	0.0285																									
		0.1038																									
		0.1796																									
		0.1534																									
	Number of drops per 1m²= 10000	0.0285													Expeiment												
		0.1038	Experiment												Experiment												
		0.1796	Experiment																		Experiment						
		0.1534							Experiment																		
Droplet Volume= 6μL	Number of drops per 1m²= 3600	0.0285																									
		0.1038													Experiment												
		0.1796																									
		0.1534																									
	Number of drops per 1m²= 6400	0.0285													Experiment												
		0.1038	Experiment												Experiment						Experiment						
		0.1796																									
		0.1534													Experiment												
	Number of drops per 1m²= 10000	0.0285																									
		0.1038													Experiment												
		0.1796																									
		0.1534																									
Droplet Volume= 9μL	Number of drops per 1m²= 3600	0.0285																									
		0.1038													Experiment												
		0.1796																									
		0.1534	Experiment																			Experiment					Experiment
	Number of drops per 1m²= 6400	0.0285																									
		0.1038																									
		0.1796																									
		0.1534																									
	Number of drops per 1m²= 10000	0.0285																									
		0.1038																									
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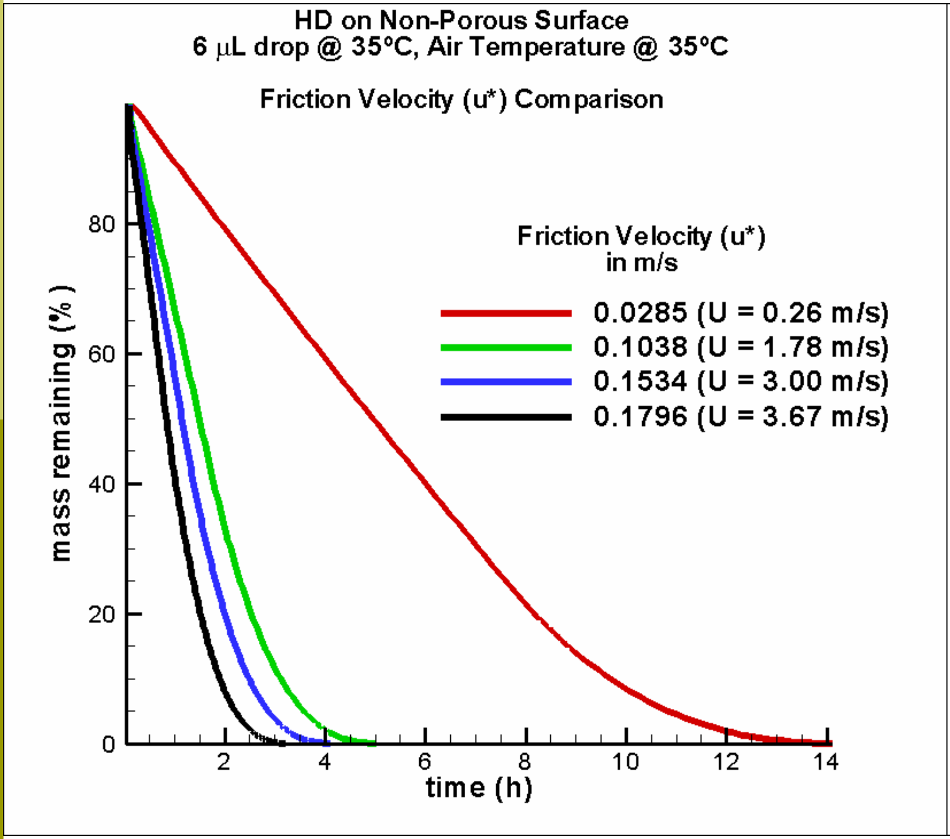
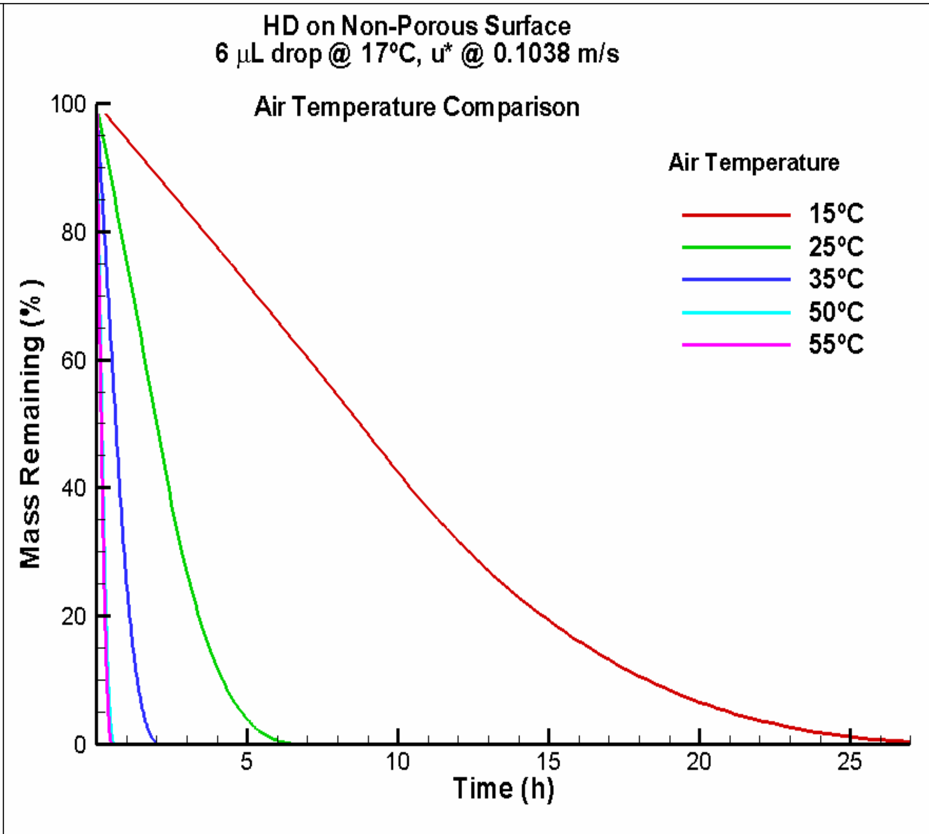
Evaporation Module (*cont'd*) HD on a Non-Porous Surface – Parametric Studies

- Effect of Velocity and Air Temperature on Evaporation





Evaporation Module (*cont'd*) Model Generalization

- All the scenarios presented in the matrix will be connected by two methods:
  - Classical curve-fit
    - ✓ To have a simple engineering tool
  - Neural network
    - ✓ To have a more sophisticated tool with prediction capabilities

Evaporation Module (*cont'd*)
Model Generalization

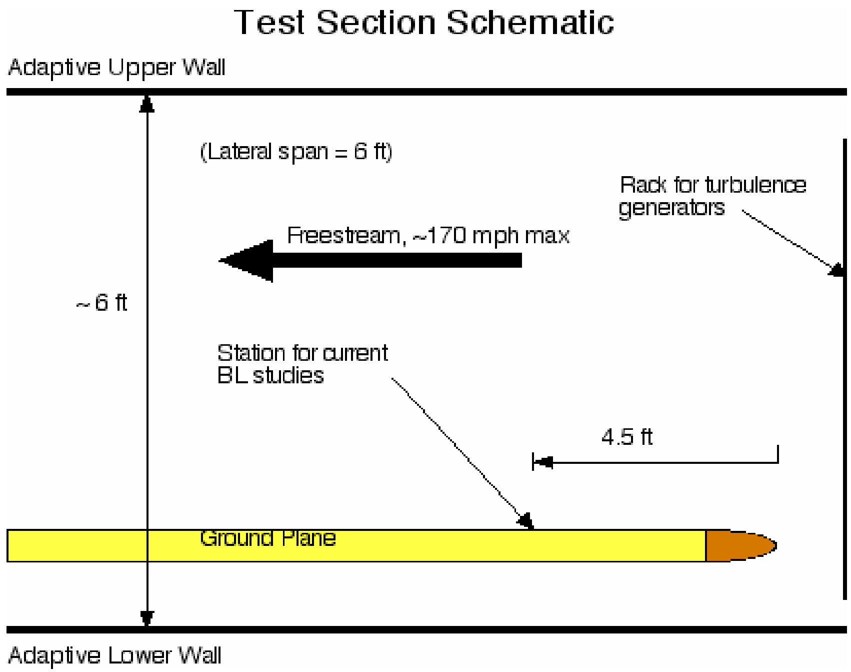
Caltech Work: Overview

- Motivating hypothesis (Navaz): The relevant velocity scale for fluid evaporation rate is not the freestream speed (U_∞), but the "friction velocity"

$$u_\tau = \sqrt{\tau_w / \rho}$$

- Variation of τ_w (and thus friction velocity) for given free stream speed demonstrated
- Simple case of drop evaporation rate evaluated experimentally
- Variation in evaporation rate with friction velocity observed
- Future experiments

John W. Lucas Adaptive Wall Wind Tunnel (GALCIT)



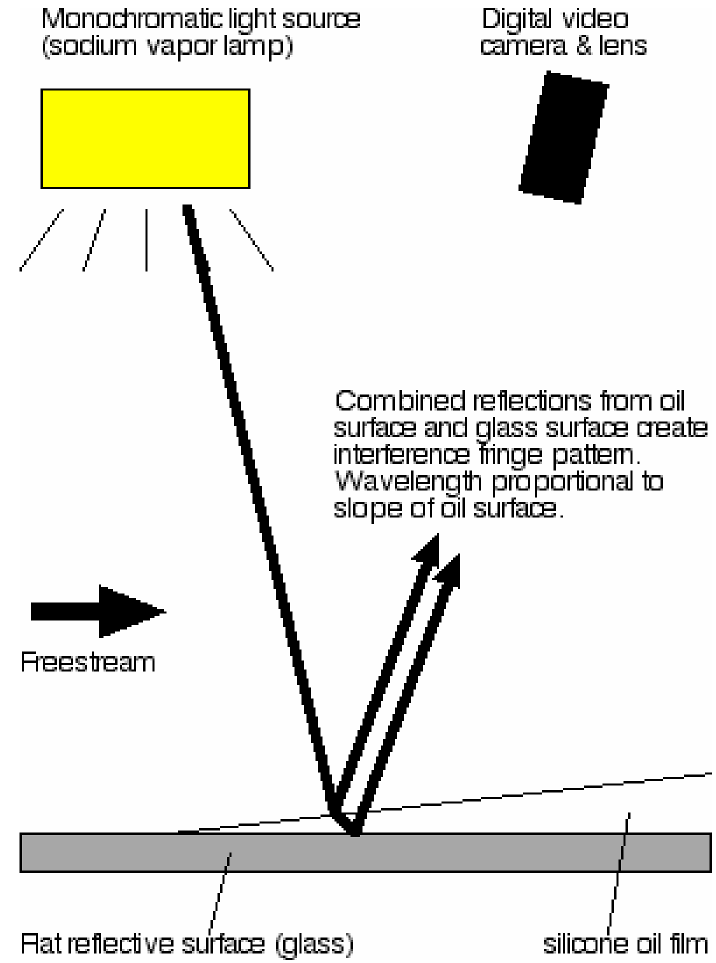
- Turbulence generators (may be) placed in rack upstream of ground plane to increase freestream turbulence level.
- Boundary layer properties examined on ground plane at specified distance from leading edge.

Free Stream Turbulence Generation

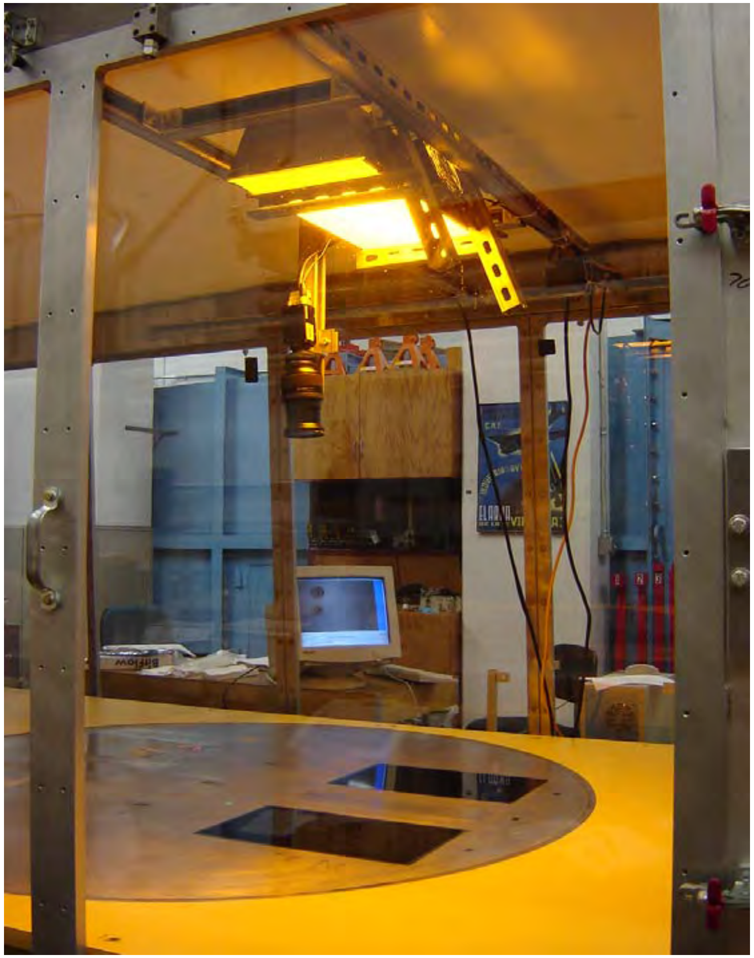
- Bungee cords stretched within frame in free stream.
- Act as turbulence generator; also vibrate quite a bit at high speeds.
- Various configurations available to “dial in” turbulence level.
- Idea: Bahram Valiferdowsi

Wall Shear Stress Measurement

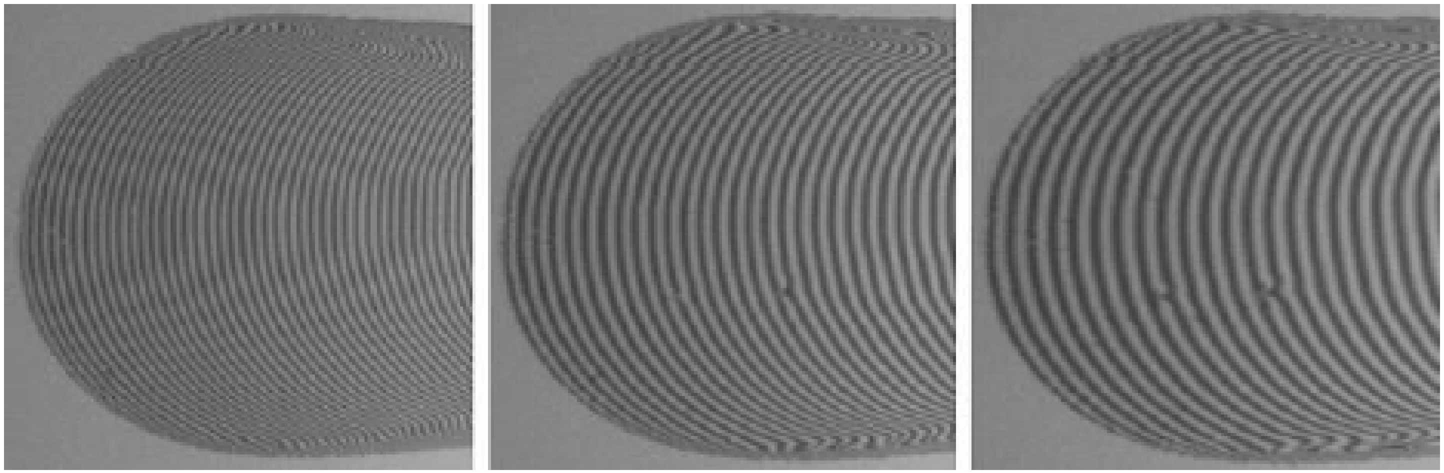
- Oil film technique used by Nagib and others.
- *Relatively* non-intrusive - camera and lamp placed in tunnel, but near test section roof.
- By observing interference fringes growing with time, wall shear stress may be calculated.



Shear Stress Measurement Apparatus



Wall Shear Stress Measurements



- Numerous images taken at 10-30 sec intervals.
- Fringe spacing growth rate, ds/dt, easy to evaluate.

$$\tau_w = \frac{2n\mu}{\lambda}\frac{ds}{dt}$$

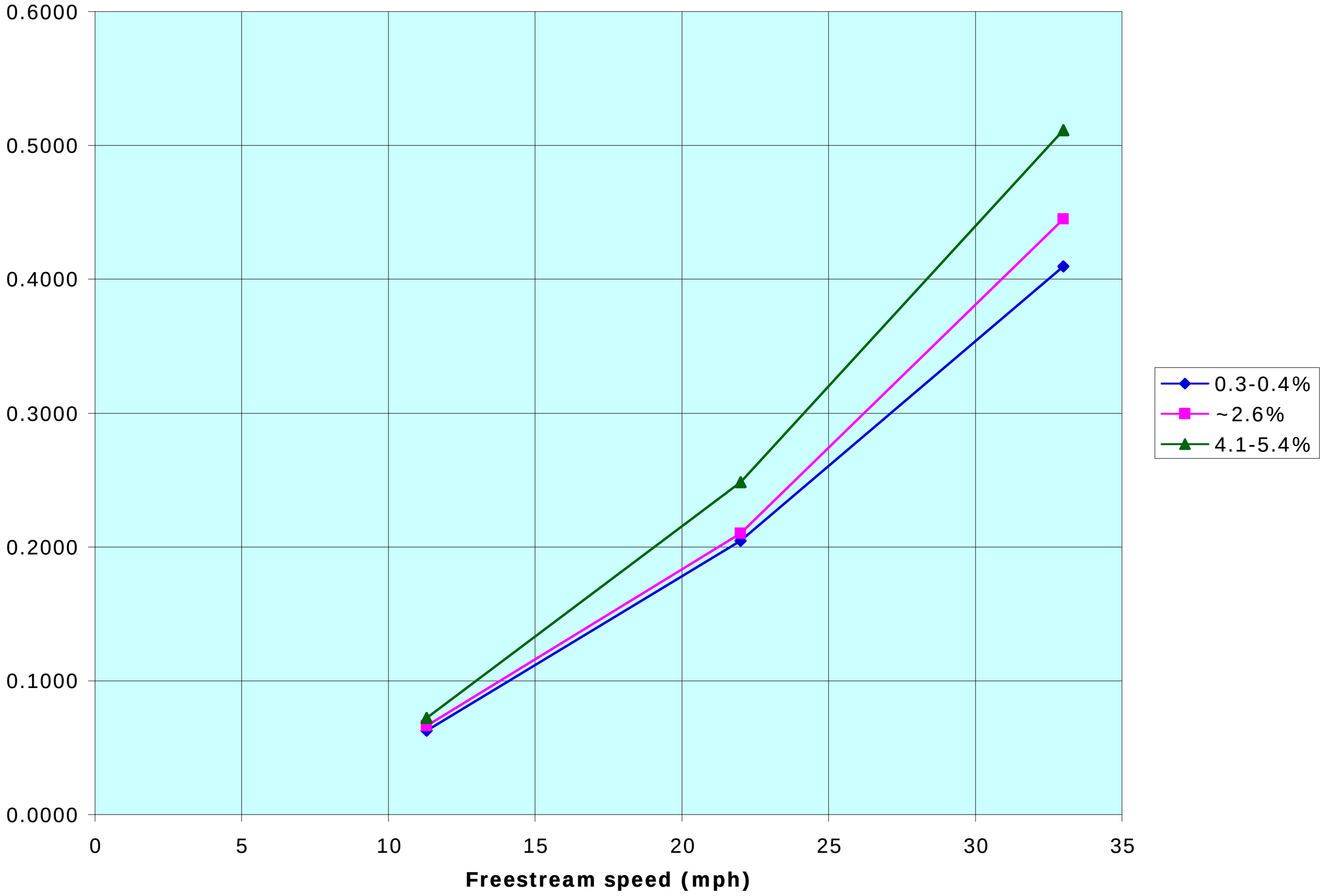
- n = oil index of refraction; μ = dynamic viscosity; λ = light wavelength.

Wall Shear Stress Variation with Free Stream Turbulence

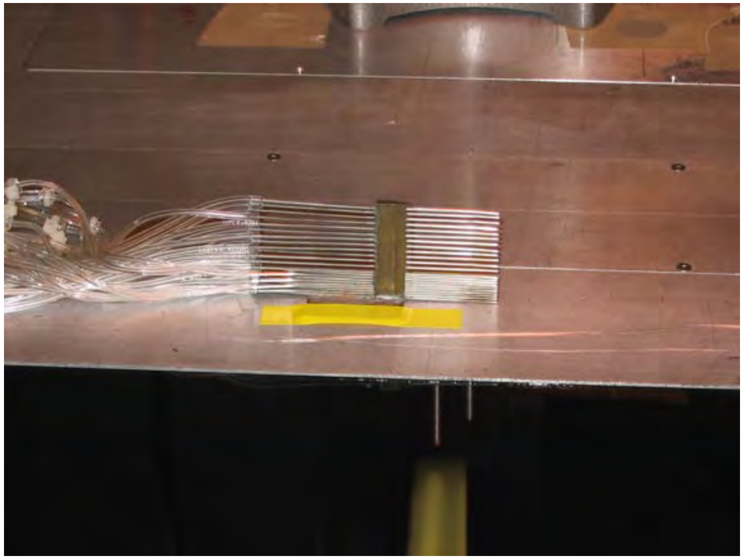
	Turbulence Level		
Speed (mph)	0.3-0.4%	~2.6%	4.1-5.4%
11.3	0.0626	0.0663	0.0723
22	0.2048	0.2102	0.2483
33	0.4096	0.4450	0.5115

- Wall shear stress (τ_w) given above in Pa.
- Notable increase in τ_w as turbulence level increases.
- Data at 1% turbulence level showed slight *decrease* in τ_w; calibration drift of pitot-static pressure transducer suspected.

Free Stream Turbulence Intensity Affecting τ_w - Plot

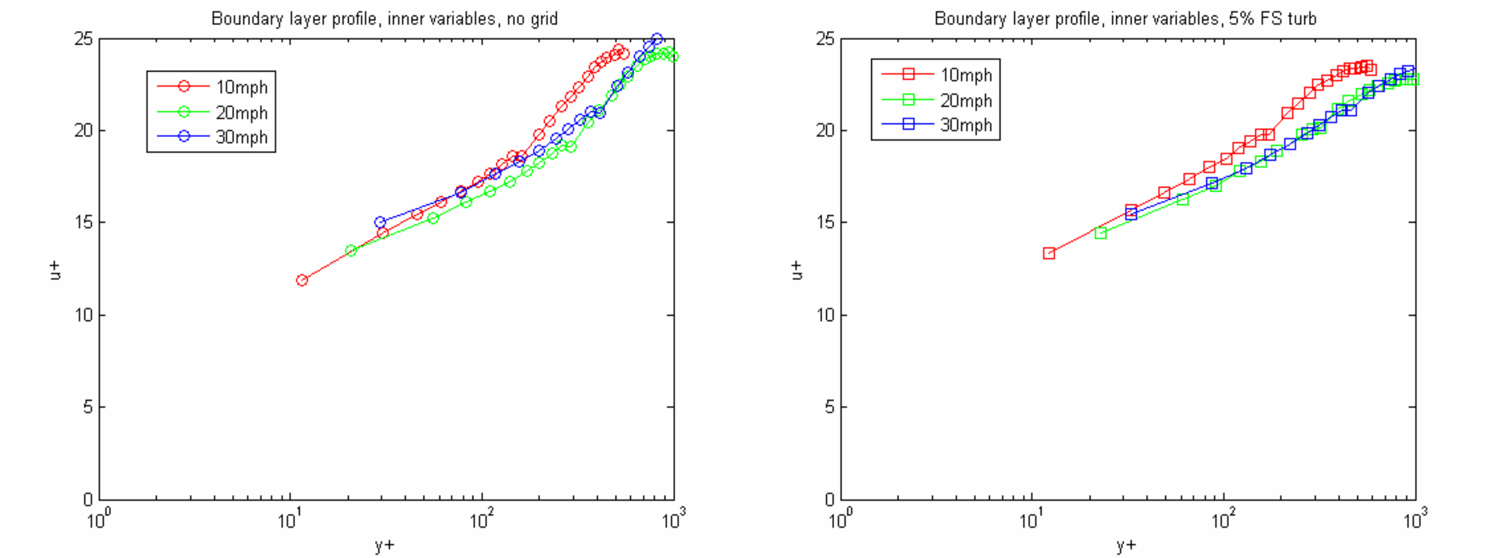


Boundary Layer Profile Measurement



- 22-element boundary layer rake used to measure dynamic pressures at select heights
- Static pressure taken from nearby pitot-static tube

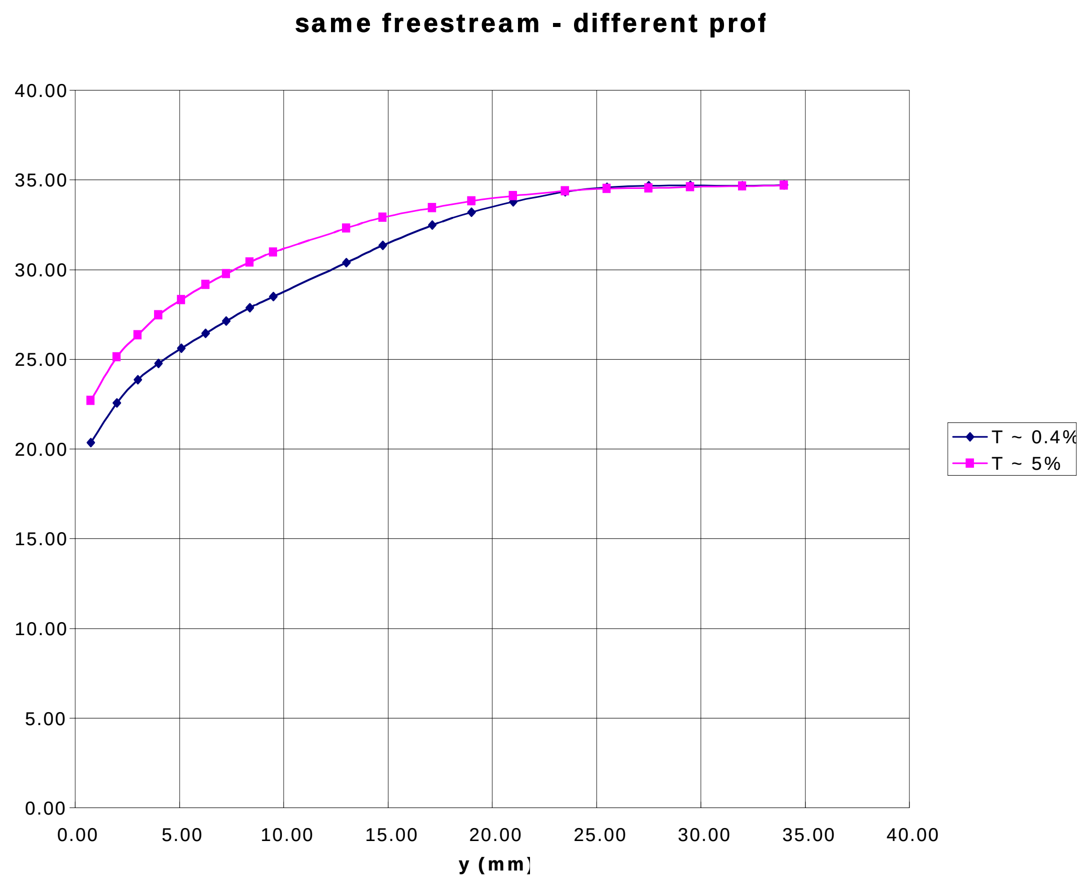
Boundary Layer Profile Comparison - ~0.4% vs. 5% free Stream Turbulence



- Both profiles follow Clauser turbulent boundary layer profile; shape changes slightly near free stream transition
- In no case is laminar sub-layer accessible ($y^+ < 5$).

Profile Shape Change with Free Stream Turbulence Level

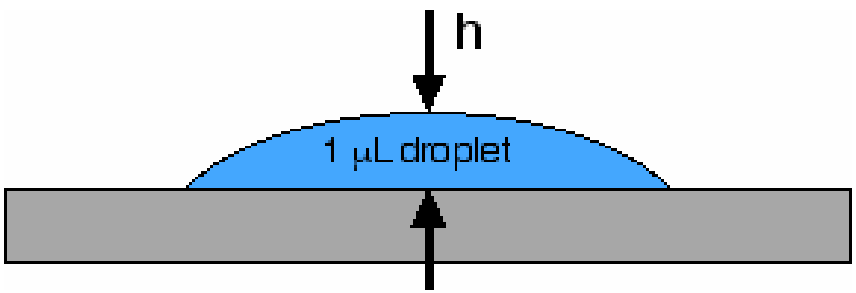
- At the same freestream speed, the shape of the boundary layer visibly varies with added freestream turbulence T.
- The higher T curve “stays high” lower, requiring a more abrupt reduction to zero.
- This agrees with the observed higher shear stress at the wall.



Critical Parameter for Evaporation: Wall Shear?

- It is hypothesized (Navaz) that evaporation rate of liquid droplets is based on the friction velocity (u_τ) rather than the free stream speed (U_∞).
- Current experiments demonstrate that for a constant U_∞, τ_w may be increased by up to 25% by imposing 5% turbulence intensity on the free stream flow.
- 25% increase in τ_w -> 12% increase in u_τ.
- Change in evaporation rate by up to 20% thus expected by model.

Relative Sizes: 1 μL Droplet and Laminar Sub-Layer

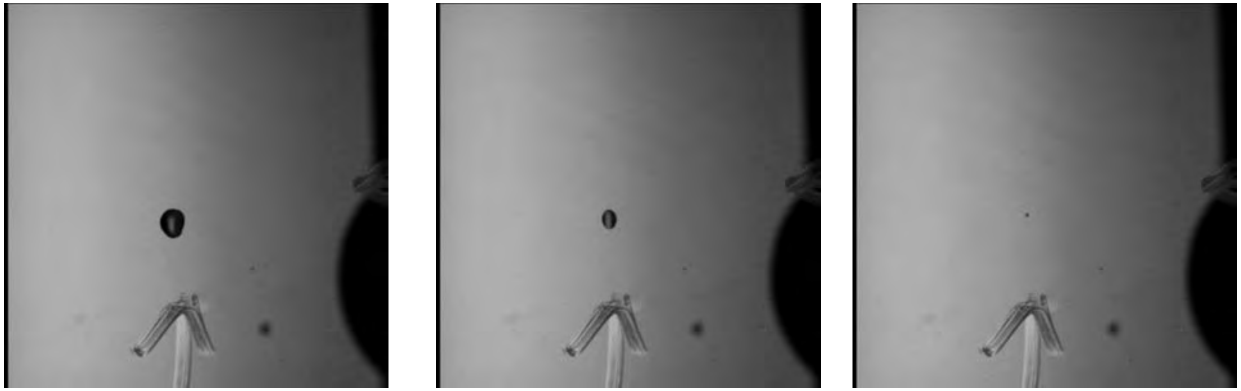


- 10 mph free stream and low turbulence level, present BL experiments
- Laminar sub-layer thickness ($y^+ = 5$) is ~ 0.3 mm
- 1 μL droplet has height *h* of ~ 0.2 mm (Navaz)
- Droplet lies entirely within laminar sub-layer, where friction velocity u_τ is the dominant flow parameter (and only velocity scale!).

Proof-of-Concept Experiment

- Evaporation rate of 2.5 ml water drop in 10 mph free stream examined at turbulence intensity levels of 0.4% and 5%.
- Droplet dispensed on glass, video camera observes evaporation.
- Ensembles for each case taken, mean evaporation time recorded.

Droplet Evaporation Experiment



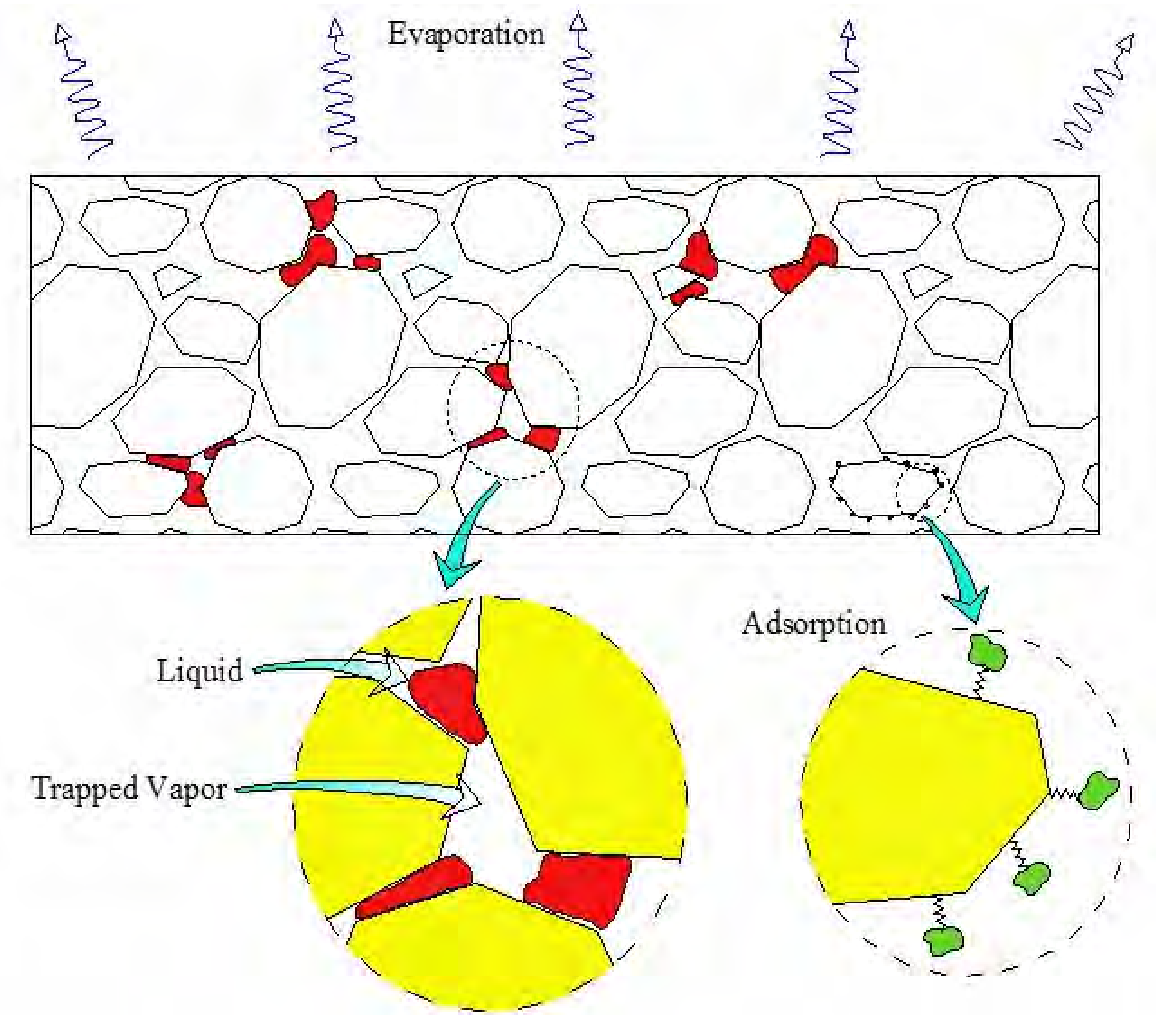
Turbulence intensity level (%)	0.4	5
Friction velocity (m/s)	0.23	0.25
Mean drop evaporation time (sec)	**900**	**850**

Upcoming Work at Caltech

- Evaporation rate measurement
  - Instantaneous rate measurement
  - More accurate optical techniques
  - Mass measurement (microbalance?)
- Still higher turbulence intensity levels
- Further collaboration/verification with numerical model of H. Navaz
- Different surfaces (concrete, etc.)

Evaporation Module
Link to the Porous Surface

- Simultaneous process present with evaporation
  - Capillary diffusion
  - Secondary evaporation
  - Vapor entrapment
  - Adsorption



Porous Media/Substrate Modeling Observations

- Liquid simulants established a finite network in a porous domain (Czech concrete)

Porous Media/Substrate Modeling Proposed Approach

- Modeling effort
  - Solve the governing equation by capillary network model (CNM)
- Verification effort
- Generating the Design of Experiment matrix
- Obtaining solution for the entire matrix
- Curve fitting
  - Classical
  - Neural Network

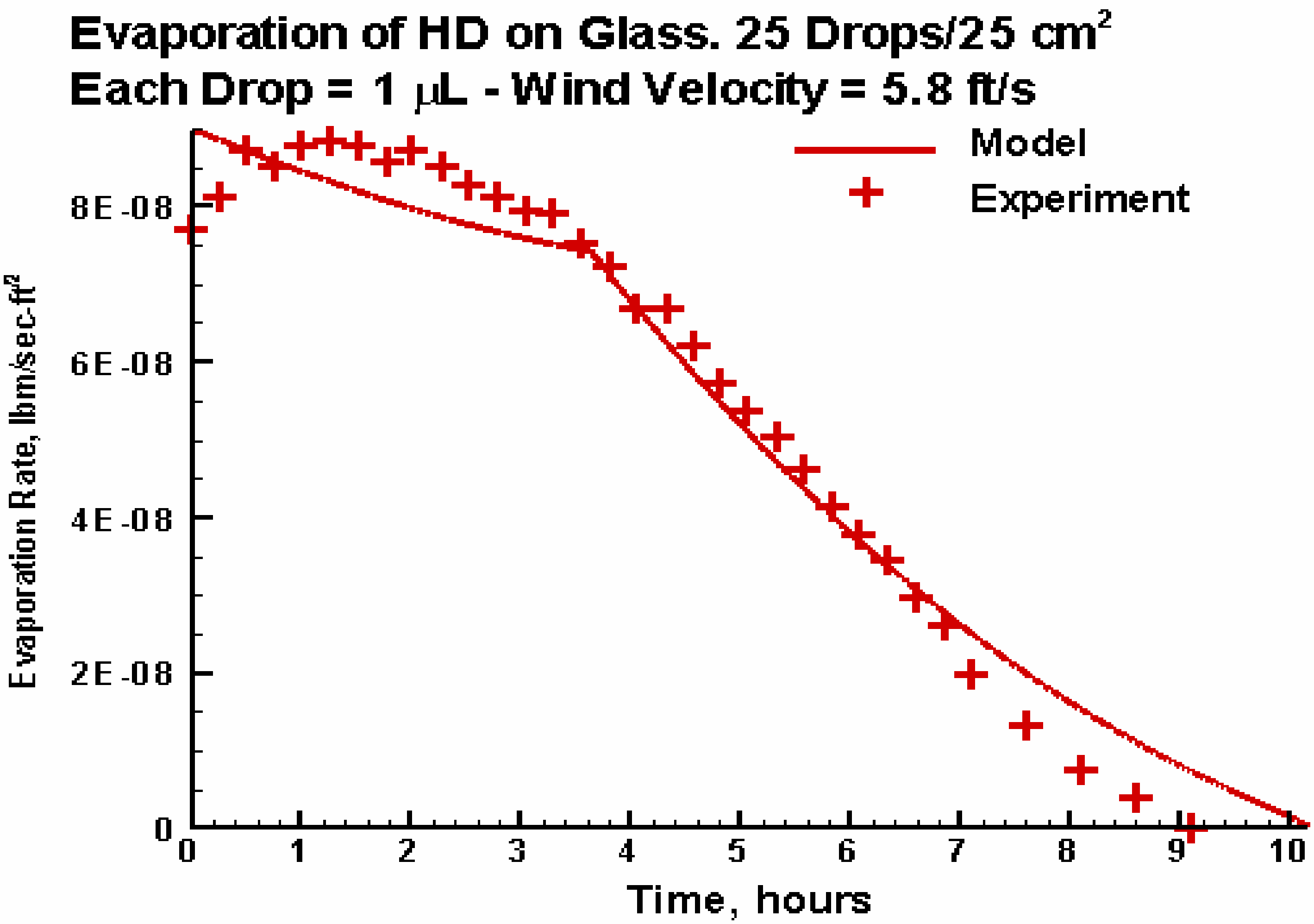
Porous Media/Substrate Modeling Adding Adsorption Model

- Add adsorption model to the porous substrate model
- Ensure robustness of the algorithm
- Validate model by
  - Conducting laboratory tests
- Verify the model
  - Laboratory
  - Outdoor

Conclusion

- Developed an evaporation model
- Verified the model with experimental data
- Extended the domain of applicability by using a hybrid analytical/experimental method
- Developed a framework for tackling a more complex problem – HD on porous substrate
- Resolving wind/turbulence/shear stress issues
- Incorporating the effects of wind turbulence intensity on evaporation

Evaporation Rate Validation



Science & Technology for Chem-Bio Information Systems (S&T CBIS) Conference

Providing Capabilities-Based Analytic Support In Dynamic Operational Environments

Albuquerque, NM
26 October 2005

Booz | Allen | Hamilton

Table Of Contents

- Why Event Drivers
- Use Cases and Architectures
- DOTMLPF Support
- End-to-End Documentation

Scenarios, Use Cases and Mission Threads Provide…

- A ***common baseline and lexicon*** to facilitate discussion between operators, systems engineers, software engineers, developers, and architects

- A consistently executable analysis and management tool to address the development, synchronization, monitoring, assessing, and refining of joint warfighter capabilities across the DOTMLPF spectrum and across Warfighting Domains

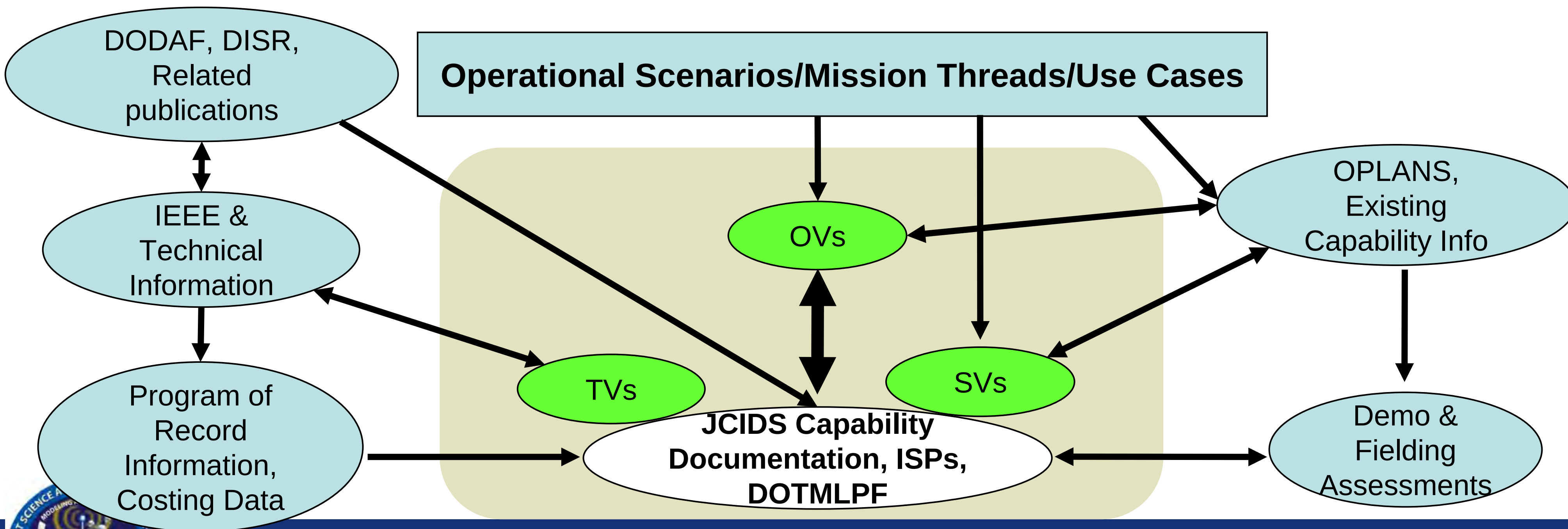
- A conduit for moving capability development along a spiral evolutionary pathway toward the net centric goals of Joint Operational Concepts, Joint Integrated Concepts, and Joint Functional Concepts

- **Tied with systems – allows for direct tie to Acquisition decision-support.**

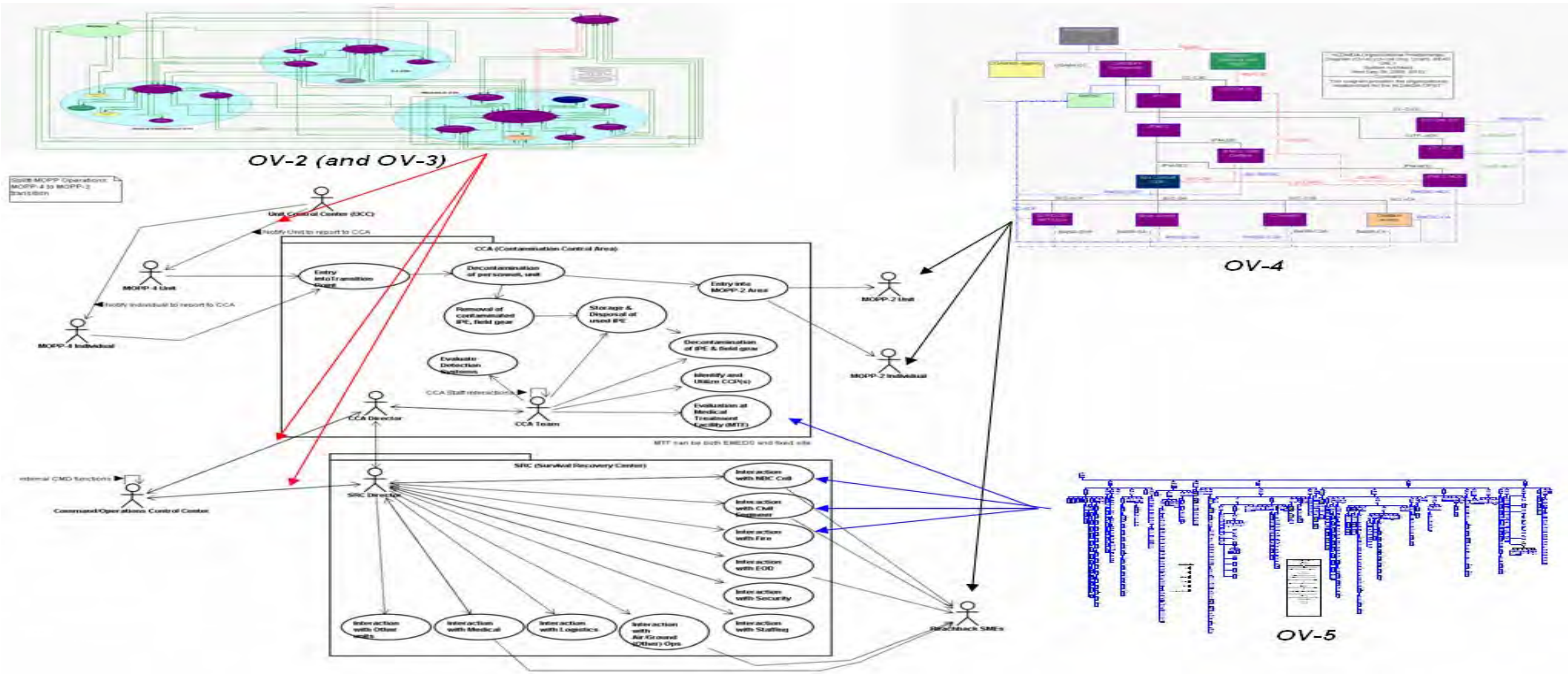
Mission Threads/Use Cases - a Common Integrating Core Across Warfighting Operations, Systems And Processes

Operational Scenarios, Mission Threads, and Use Cases Assist In Structuring the Overall Architecture

- Allows for quick relationships to architecture products and development of Demonstration & Exercise Plans and Data Collection and Analysis Plans (DCAP) for *Execution*…

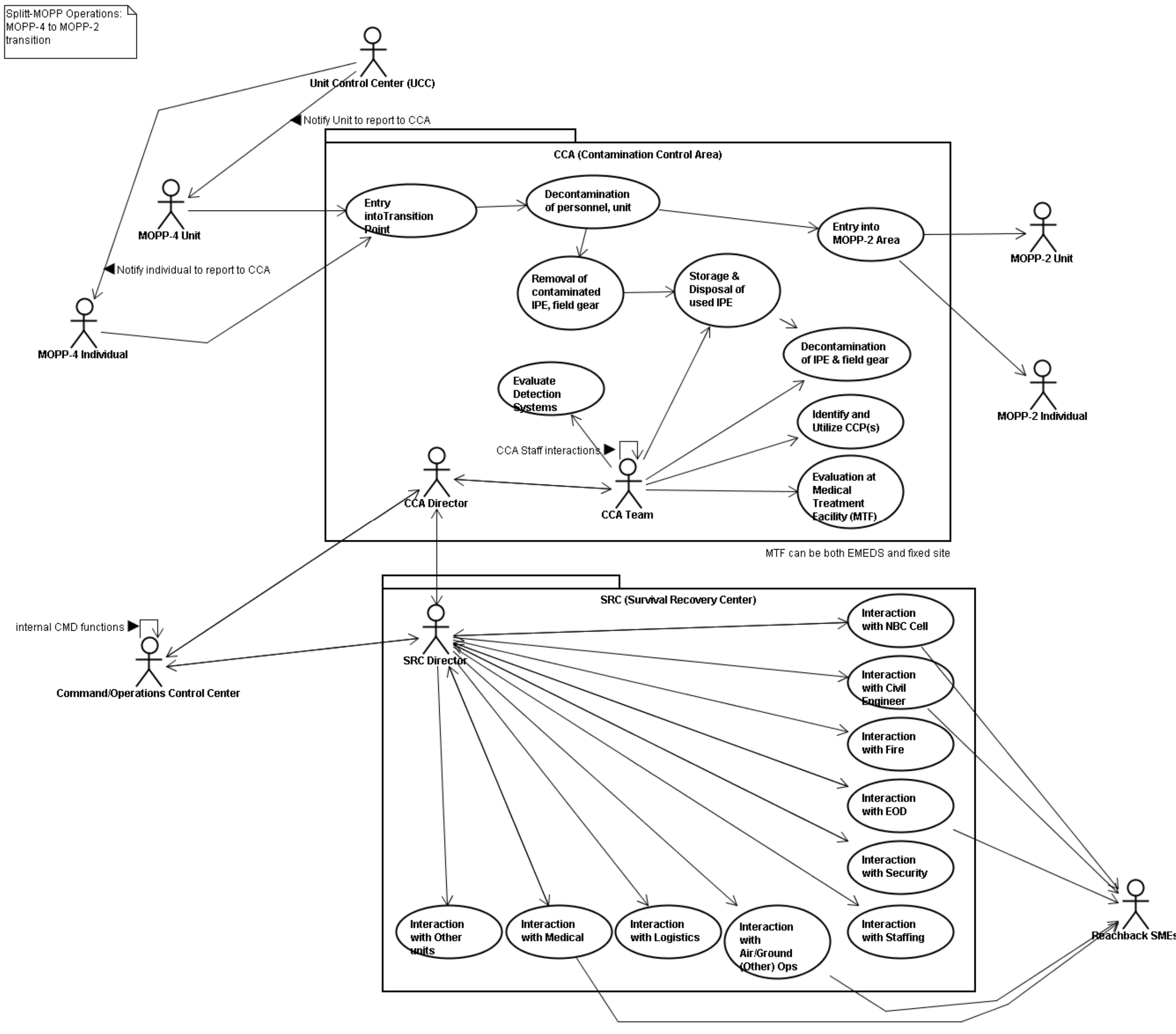


Operational Scenarios, Mission Threads, and Use Cases Structure the Overall Architecture



- … and tighter architecture and requirements refinement spirals for *requirements and regulatory needs*.

Developing And Implementing Use Cases



- **Provides Context to the Architecture By Providing a use case or set of use cases within a scenario**
- **Easily Understood By Most Engineers and Easily Explained To Operators and End Users**
- **Provides a set of potential needs and capabilities to use in T&E and Exercise events**
- **Supports MSELs, DCAP, and ExPlans**

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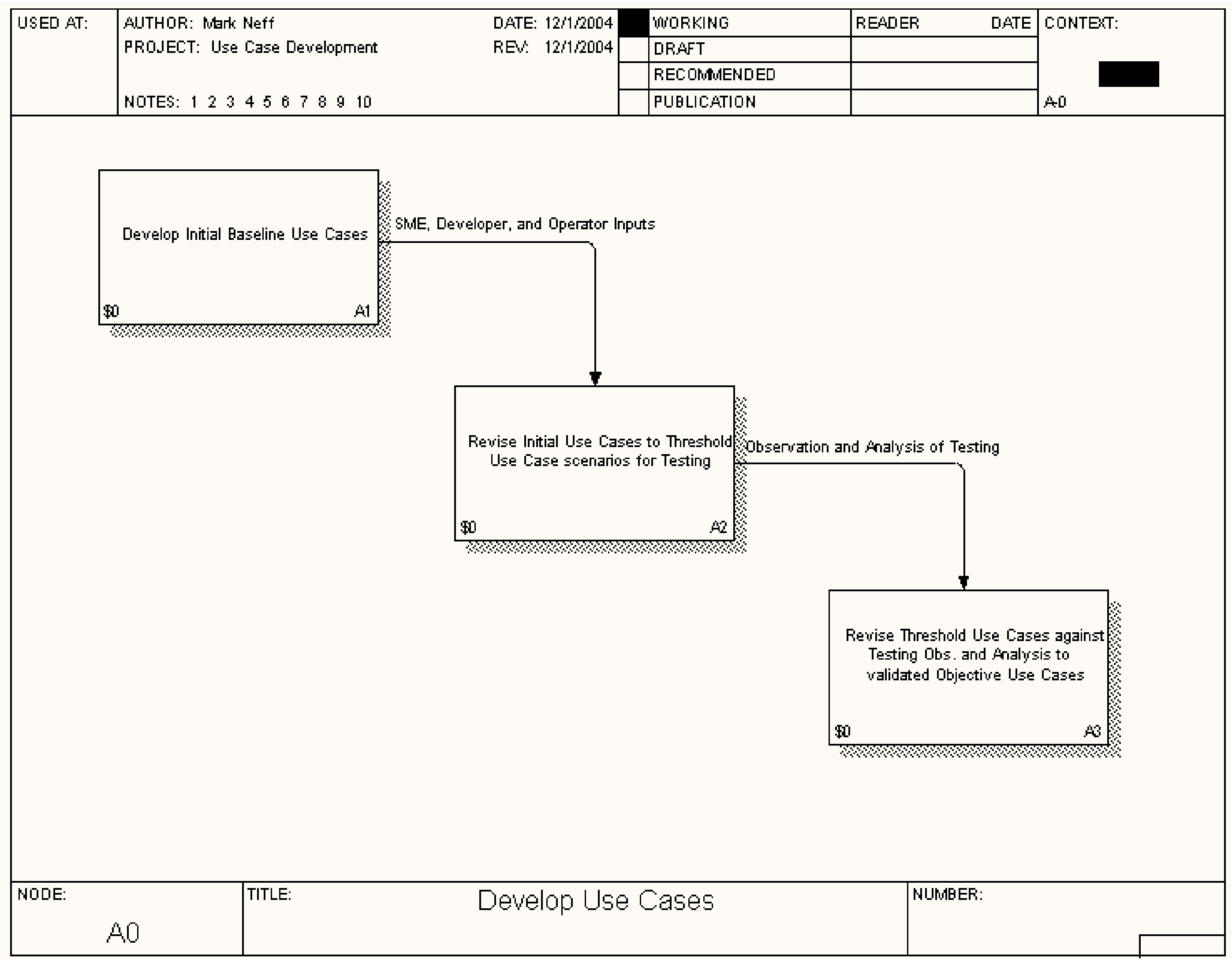
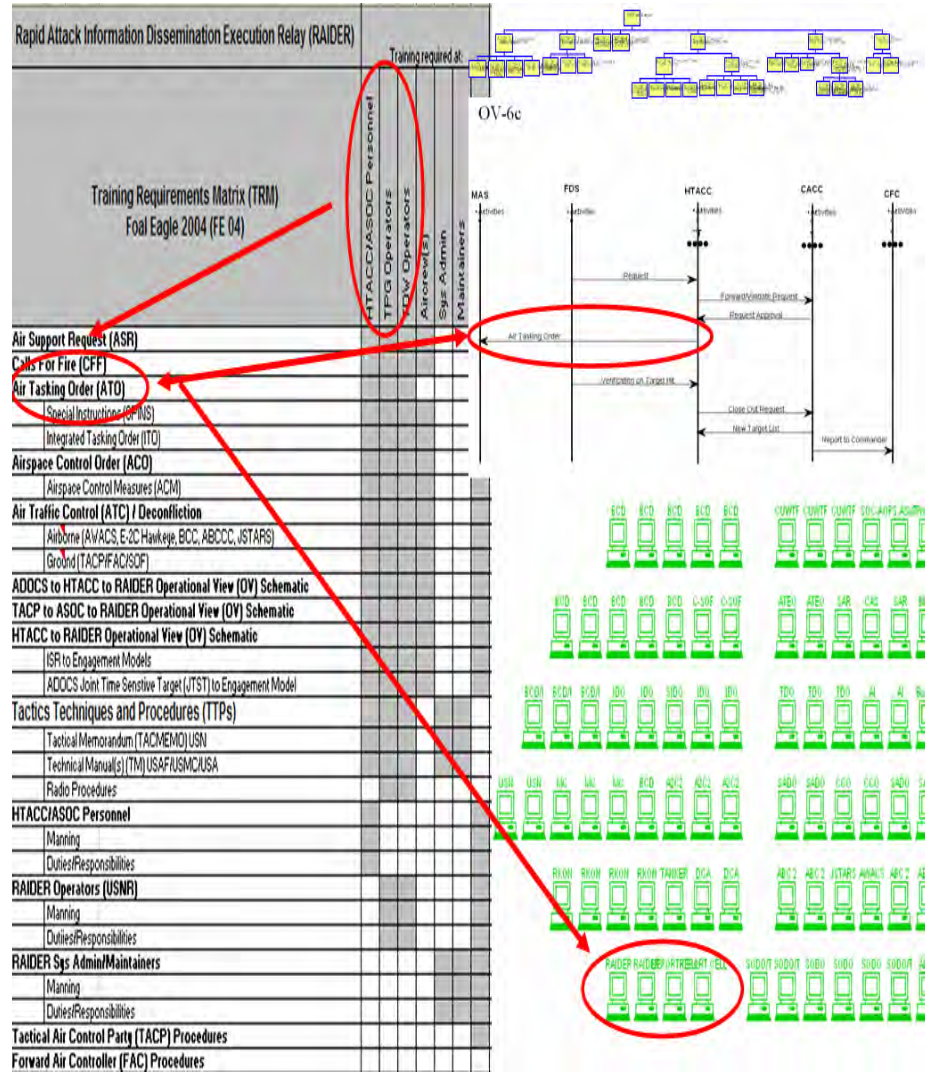
Process Layout: Use Case Development



- **Process Supports**
  - **Initial Development**
    - **For discussion and warfighter inputs**
  - **Threshold Refinement**
    - **Verification of by warfighters, engineers, and developers**
    - **Analysis**
  - **Objective Validation**
    - **T&E, Analysis**

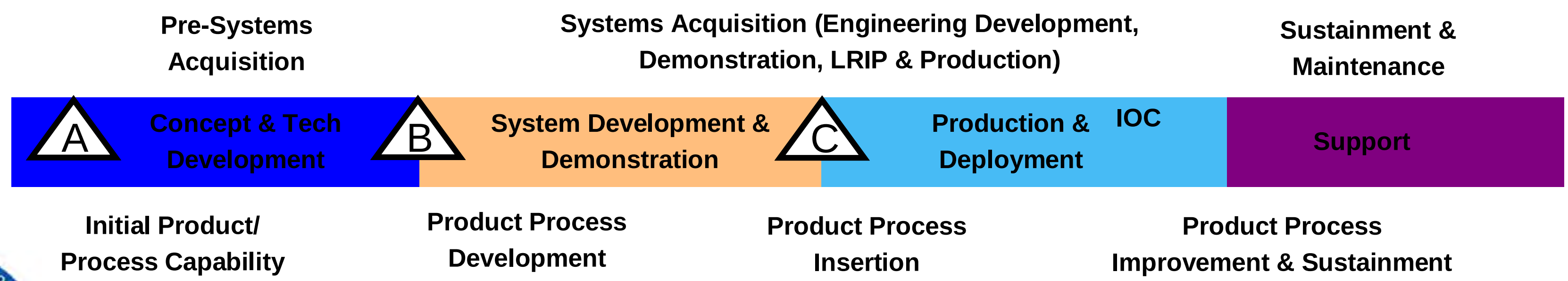
Capability-Based, Event-Driven Analysis Supports DOTMLPF Needs

- Event Drivers (Scenarios, Threads, and Use Cases) and the subsequent analysis and tools provide the capture and dissemination of war fighter needs to rapidly transition to capability solutions while ensuring required data capture and documentation via overarching architectures and JCIDS requirements.



Capability-Based, Event-Driven Analysis Supports DOTMLPF Needs

- Using this methodology ensures both *rapid delivery* of War fighter capability and continued *sustainability* and *enhancement* to the capability delivered.
  - "Event-Driven" provides quick Return-on-investment through requirements development, testing, analysis, validation, and solution identification.
  - "Capability-Based" provides the integration, linkages, data capture, architecture refinement, and documentation to meet POM and POR requirements for sustainment and enhancement.



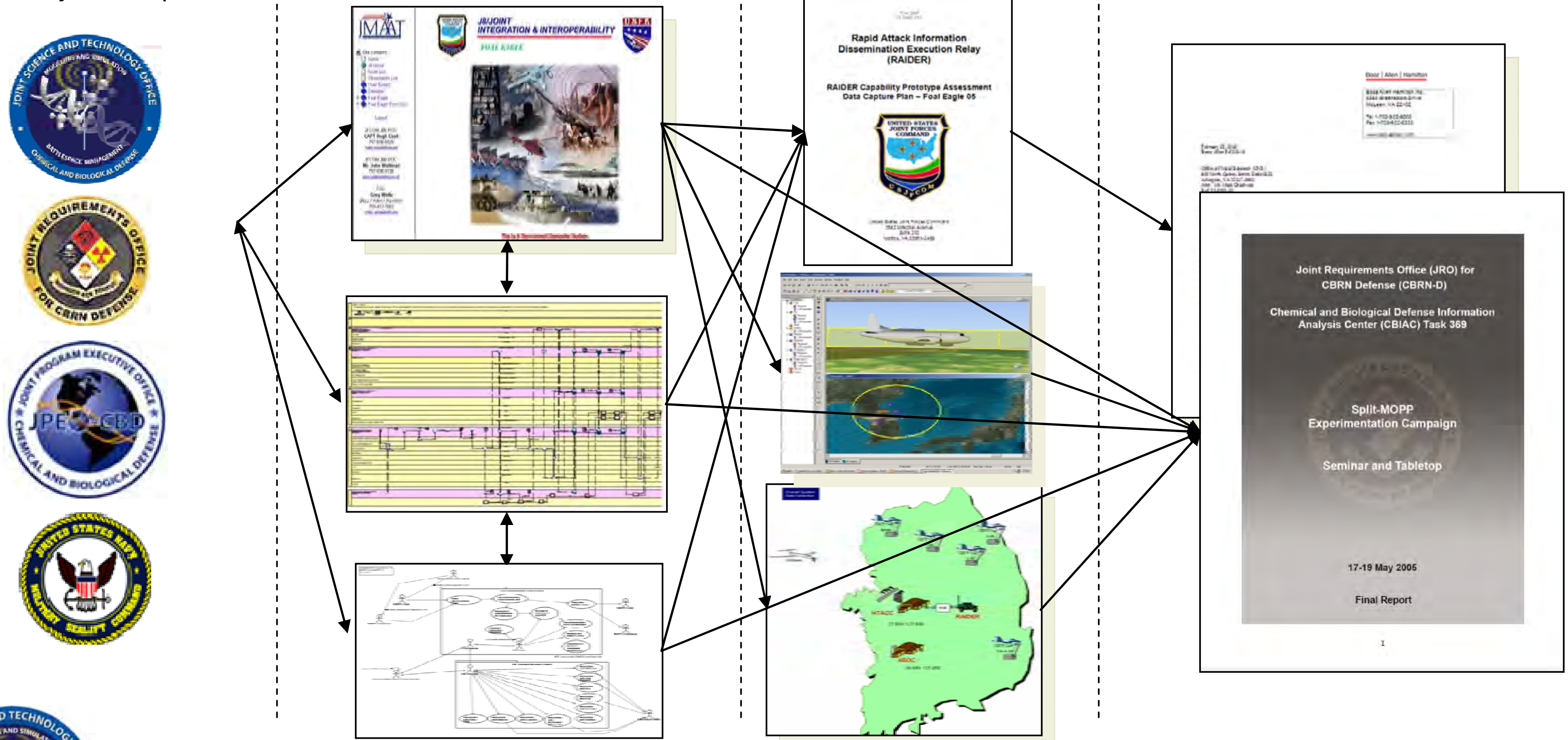
Event Drivers Such As Use Cases Ensure Linkages & Tie-Ins Leading To End-to-End Documentation

Requirements
Urgent Needs, IPLs, L/Ls
Capability Development

Concepts
CONOPS, Mission
Threads, Use Cases

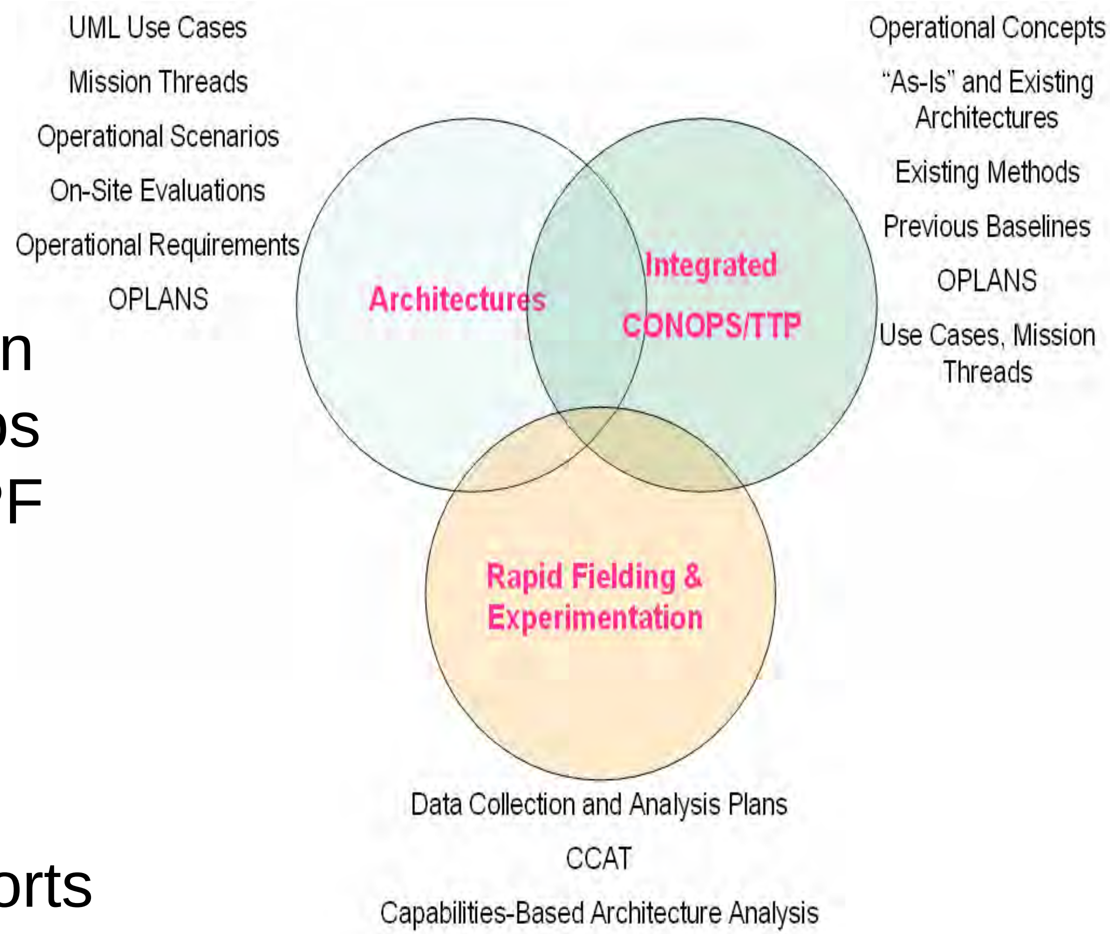
Data Collection & Analysis
Architectures, M&S

Final Report/Deliverables



Capability-Based Event Analysis Ensure Linkages & Tie-Ins Leading To End-to-End Documentation

- Ensures direct linkage to OPLANs, CONOPS/TTP, UJTLs, etc.
- Ensures rapid identification of deficiencies and overlaps & recommended DOTMLPF solutions
- Leverages and integrates existing and developing architectures and M&S efforts



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Methods for Understanding Human Interface Requirements for Decision Support Tools

Decision support tools for CB program at DTRA

Bill Ogden, Jim Cowie, Chris Fields

New Mexico State University

Goals of our methods.

- Address assumptions and raise questions in the context of predicted use.
  - Who exactly is the user?
  - What questions they will need to answer?
  - What information will they need?
  - Will the decision support be accessible?
    - Usable , Learnable, Useful, Timely
- Give development team members and stakeholders a venue for discussion.
- Identify gaps in functionality.
- Goal is a habitable decision support system

Who are the users? Storyboard and personas

- We want to be as explicit as possible as this will determine the validity of whatever story is told.
- Personas are hypothetical archetypes, or "stand-ins" for actual users that drive the decision making for interface design projects.
- Personas are not real people, but they represent real people throughout the design process.
- Personas are not "made up"; they are discovered as a by-product of the investigative process.
- Although personas are imaginary, they are defined with significant rigor and precision.
- Personas are defined by their goals.

Methods for developing personas

- Gather data from potential users
  - Observations and ethnographic interviews
  - Representative users will be asked open-ended questions about their jobs and goals.
- Data is used to synthesize representative models of users.

- Looking for volunteers at today’s conference

Questions about the user

- Experience in the subject domain.
  - Are they experts in CB?
- Experience with the task
  - Making S&T allocation judgments
- Experience with other software tools
  - What computer skills can be expected?
- Time constraints with other job activities
  - How much time will they have to learn and use the tool?

Possible personas

- Director – High level decision maker
  - Military background
  - Some domain expertise
  - Sets direction for S&T in the whole division (e.g. CB)
    hands on user?
- Unit Program Manager
  - Science/quantitative background
  - Understands dominate methods in domain area
    we would need specific examples
- Program officer
  - Significant domain experience.
    - E.g. chemical weapons analyst.
  - PhD in science or engineering.
    Do we focus on allocations to this level of users?

Example Persona

- Roger is a DTRA program manager (PM) responsible for specific remediation type
  - His Area is Personal Protective Equipment (PPE),
  - PhD in Nuclear physics
  - Vaguely familiar with optimization theory
  - No experience with DSS architectures
  - DOES have expertise in his area
  - Has history with the agency in ongoing projects
  - Has mastery of Power Point and MS Excel
    what other tools?

Motivations behind these questions?

(1) What is the most effective application of $X for the program ?
(2) What is the most effective application of an additional $X investment ?
(3) How can the impact of an X% budget cut be minimized ?
(4) What is the effect of re-allocating $X from area 1 to area 2 ?
(5) Is an X% improvement in capability 1 more expedient than an X% improvement in capability 2?
(6) Is an X% improvement in capability 1 through technology more cost-effective than the same improvement achieved through operational procedures?
(7) What is the sensitivity of the results based on changes to the environment space?
(8) What is the sensitivity of the results based on changes to importance of criteria ?

We need to develop at least one storyboard for each question.

Storyboard example

- Roger is given an additional $5 million to fund projects in his office. (PPE) Question 2
  - Possible goals? (These determine interaction style)
    - To decide the best way to allocate money to existing proposals – focus on immediate needs
    - To understand what effect funding different remediation capabilities would have on likely attacks – focus on exploration of the effects of improved capabilities
    - To understand what remediation capabilities are in critical need of more funding
    - … others?

Goal: To decide the best way to allocate money to existing proposals

The user has a list of costs associated with different remediation capabilities.

- 10 – 20 proposals? 1-10 year time frames? Projects addressing multiple remediation types? Information in a spreadsheet?

The user selects an optimization mode for the tool and sets $5 mil as the target funding.

He would like to focus just on the remediation capabilities for which he has proposals

- set funding for other remediation types at zero? May want to earmark some at a fixed level. Considers changing cost functions to reflect proposal.

Goal: To decide the best way to allocate money to existing proposals

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Requirement statements $\Rightarrow$ Use cases

Goal: To decide the best way to allocate money to existing proposals

The user has a list of costs associated with different remediation capabilities.

- 10 – 20 proposals? 1-10 year time frames? Projects addressing multiple remediation types? Information in a spreadsheet?

The user selects an optimization mode for the tool and sets $5 mil as the target funding.

He would like to focus just on the remediation capabilities for which he has proposals

- set funding for other remediation types at zero? May want to earmark some at a fixed level. Considers changing cost functions to reflect proposal.

Input range statements

Goal: To decide the best way to allocate money to existing proposals (cont)

- The result shows money allocated across remediation categories
  - How well does this map into the task of making proposal decisions (e.g. do the remediation categories reflected in the tool match the remediation capabilities under consideration?
  - Will Roger want to “add” new remediation capabilities to existing scenarios, by specifying a consequence-remediation function?
  - Roger will want to understand and possible change the remediation-cost function given considered proposals.

To understand what effect funding different remediation capabilities would have on likely attacks

- Experiment with improvements in different remediation capabilities.
  e.g. What are the consequences of a protective suit that can be worn 72hrs?
  (v) Is an X% improvement in capability 1 more expedient than an X% improvement in capability 2?
- Different technologies effect suit performance and they need to be convertible to a single scale… dollars on the input, displayed consequence on the output?
- Roger selects “interactive mode” and enters dollar amounts and views displayed consequences.
- How does he use this information… Power point slide?

What is lacking in this example

- Details…
  - What remediation capabilities?
  - What consequences matter to Roger.
  - How much time does Roger have?
  - …
- Realism?
  - Does Roger (someone like him) exist?

What's next?

- Develop DTRA CB personas.
  - Use open-ended interviews
  - Looking for volunteers at this conference
  - Iterate among DTRA partners and stakeholders
- Develop storyboards for each major question
  - Iterate among stakeholders (users if possible) and development team

Overview of Hazard Prediction Modeling Program

John Pace

Joint Science and Technology Office
Defense Threat Reduction Agency

CBIS S&T Conference Working Group Session
26 October 2005

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Environmental Hazard Prediction

- Why we're here: Warfighter support through technical improvement of JEM, JWARN, JOEF
  - Primarily supporting JEM
- Program structure focused on known limitations in dispersion modeling capabilities
  - Need for continued progress in dispersion modeling and related work *in particular areas*
  - Anticipate CBDP budget cuts in FY07
  - We need to continue making good progress to enable defense of our budget and projects

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Environmental Hazard Prediction Thrust Area Evolution

- Past: DoD environmental hazard S&T performed mostly independently by DTRA, Navy, Army
  - Lack of coordination within DoD
    - Duplication in some areas
    - No capability or programs in other areas
- Last year: Began to coordinate efforts
  - Developed S&T plan, addressing joint program needs
  - Began developing, managing projects to address key areas
- Current: Integrated programs leveraging capabilities across DoD, collaboration with US govt, universities, companies, foreign countries
  - Meeting CBDP needs, reducing duplication of effort

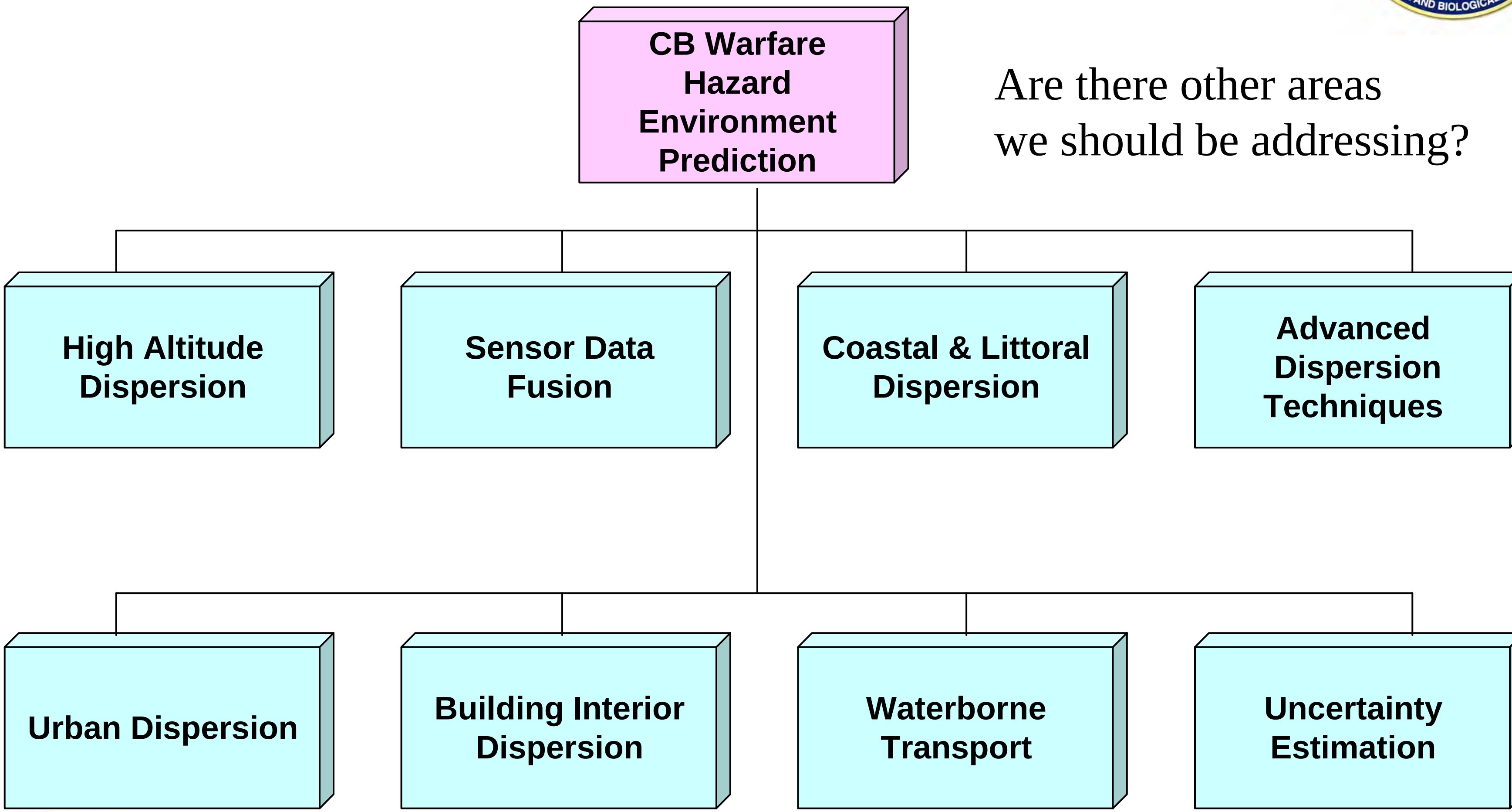
Environmental Hazard Prediction Thrust Area Objectives

- Objective: Provide technological capabilities to meet stated requirements in CB defense programs
- Provide *core system* capabilities, *enabling* capabilities
- *Core system*: components of JEM, JWARN, JOEF
- *Enabling*: provide data needed by JEM, JWARN, JOEF to function
- Requirement: Ensure technological capabilities are in place to enable JEM, JWARN, and JOEF to work, when called for by development schedules

Environmental Hazard Prediction Program Components

- Program management
- Technical guidance and support
- **Model development and acquisition**
- Enabling capability coordination
- **Experimental data**
- System integration
- Technology transition

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas



Are there other areas we should be addressing?

Future Structure – Split Thrust Area

CB Warfare Hazard Environment Prediction

Sensor Data Fusion

High Altitude Dispersion

Coastal & Littoral Dispersion

Advanced Dispersion Techniques

Urban Dispersion

Building Interior Dispersion

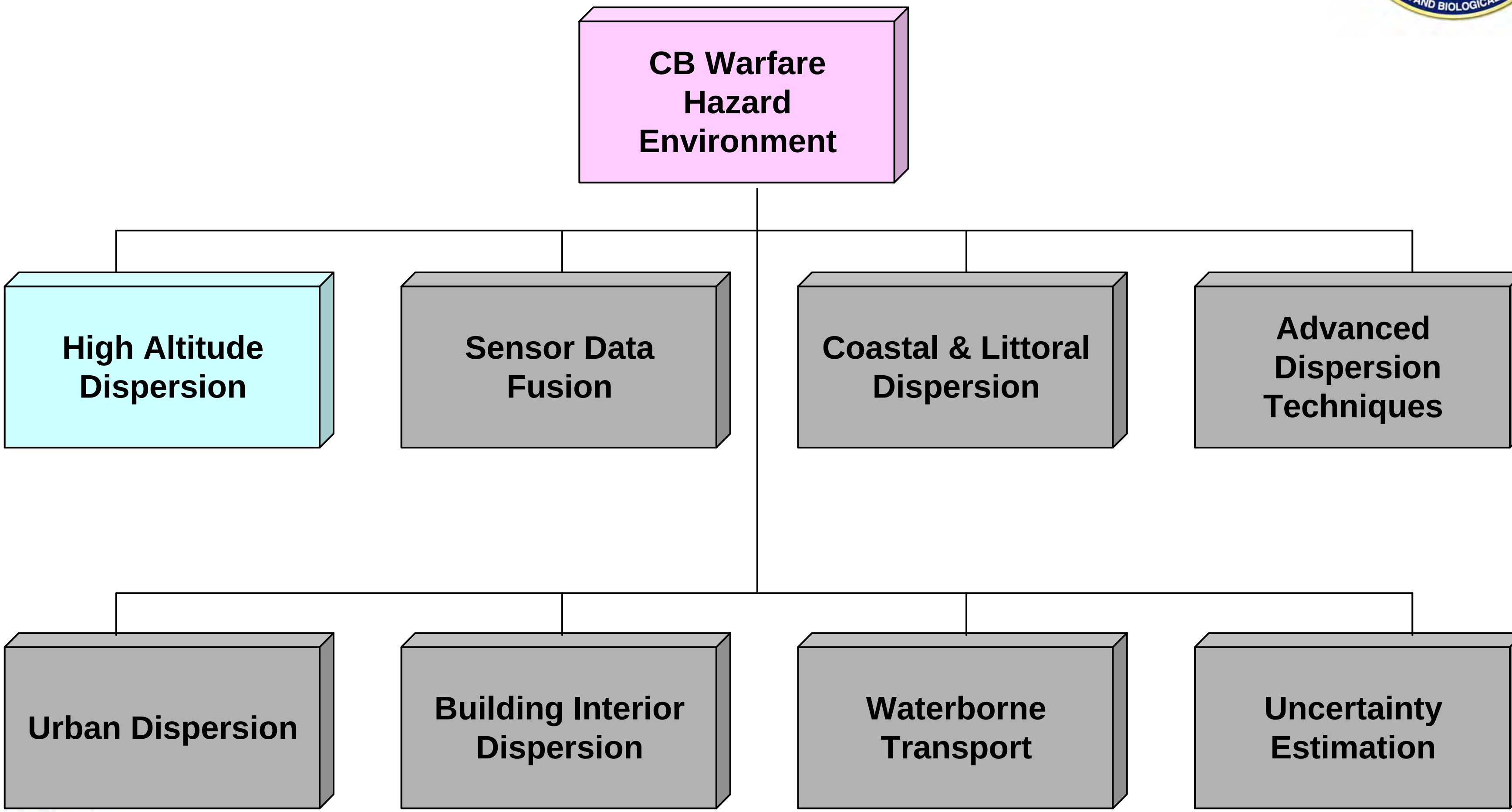
Waterborne Transport

Uncertainty Estimation

This organization chart is subject to change.

Stay tuned.

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas



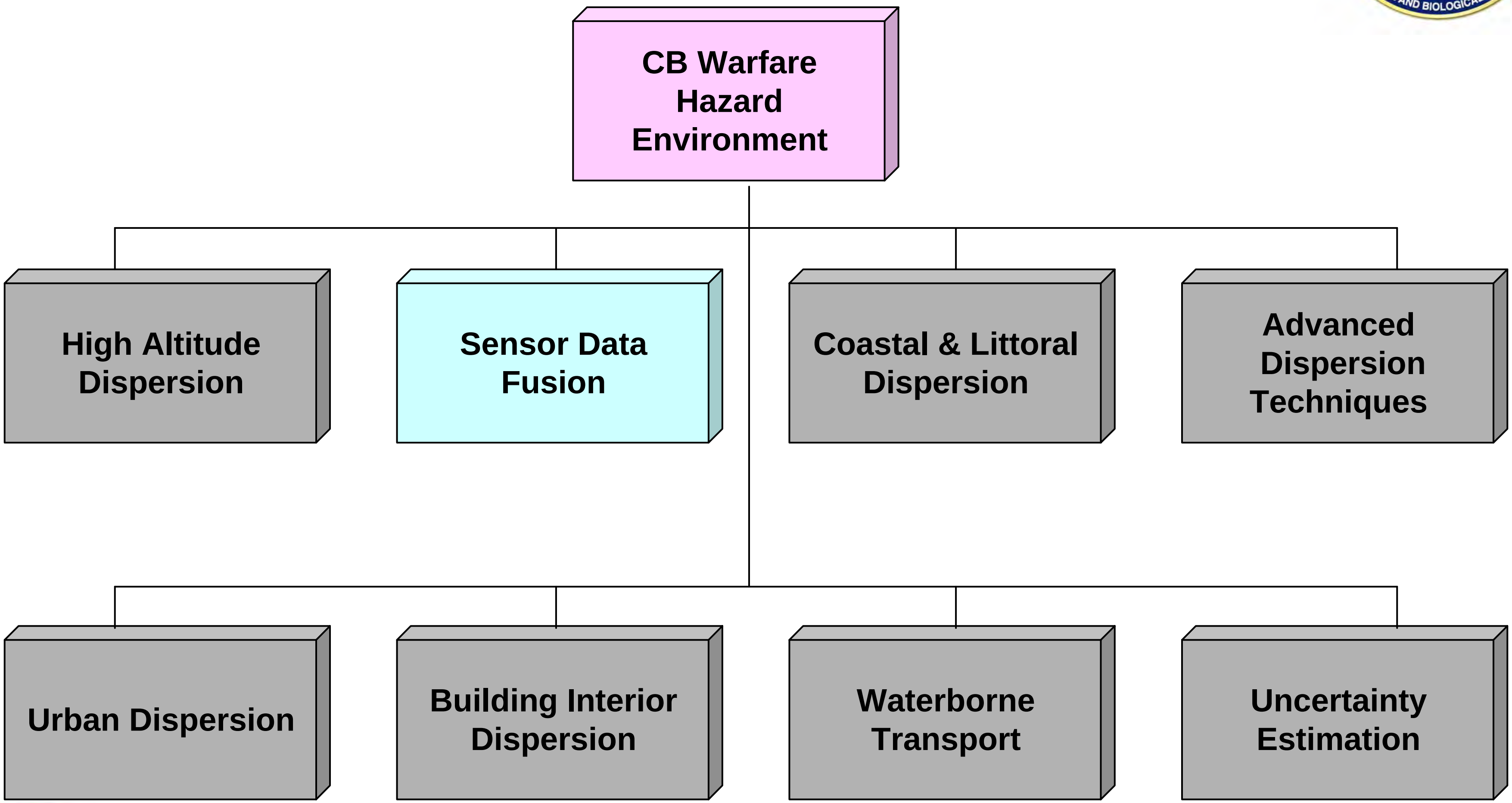
Missile Intercept Modeling

- JEM Block II requirement
- Very different from modeling in lower atmosphere
  - Thin atmosphere, different turbulence characteristics, uncertainty about behavior and characteristics of released CB materials
  - Lack real-time weather predictions

- Missile intercept source term characterization
  - JSTO is funding program at LLNL/UCSB to address source term specification: *Release and Atmospheric Dispersal of Liquid Agents* (Thursday 1330)

- High-altitude weather
  - JSTO funded project at LLNL to evaluate impact of real-time weather data
    - results show significantly different ground deposition patterns
  - JSTO expects to fund 6.1 project beginning in FY06 to study connection between terrestrial and space weather

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas



Sensor Data Fusion

- Large program to improve dispersion modeling
  - Large increase in work projected for FY06
  - Supports both JEM and JWARN
- JSTO program coordinated with TP9/TP10 program
  - Coordinates several related projects, leverages UK programs
- Principle objectives:
  - Blend CB sensor data with dispersion model
  - More accurate depiction of CB hazard area
  - Ability to “backtrack” to source location
  - Provide guidance about sensor performance
  - Support tool to place sensors for facility protection
  - Future: Extend to fusion of meteorological data

Sensor Data Fusion Presentations

- *Source Term Estimation* (Dstl)
  - Presentation, demo Wednesday 1055-1200
- *Fusion of CB Data and Model Output* (Dstl)
  - Wednesday 1300-1330
- *Chemical/Biological Source Characterization* (DTRA)
  - Wednesday 1330-1400
- *Optimizing Sensor Placement for CB Defense* (NGIT)
  - Wednesday 1400-1430
- *Sensor Location Optimization Tool Set* (ITT)
  - Wednesday 1430-1500
- *Overview of Mesoscale Modeling for Dispersion Applications* (NRL Monterey) – Wednesday 1500-1530

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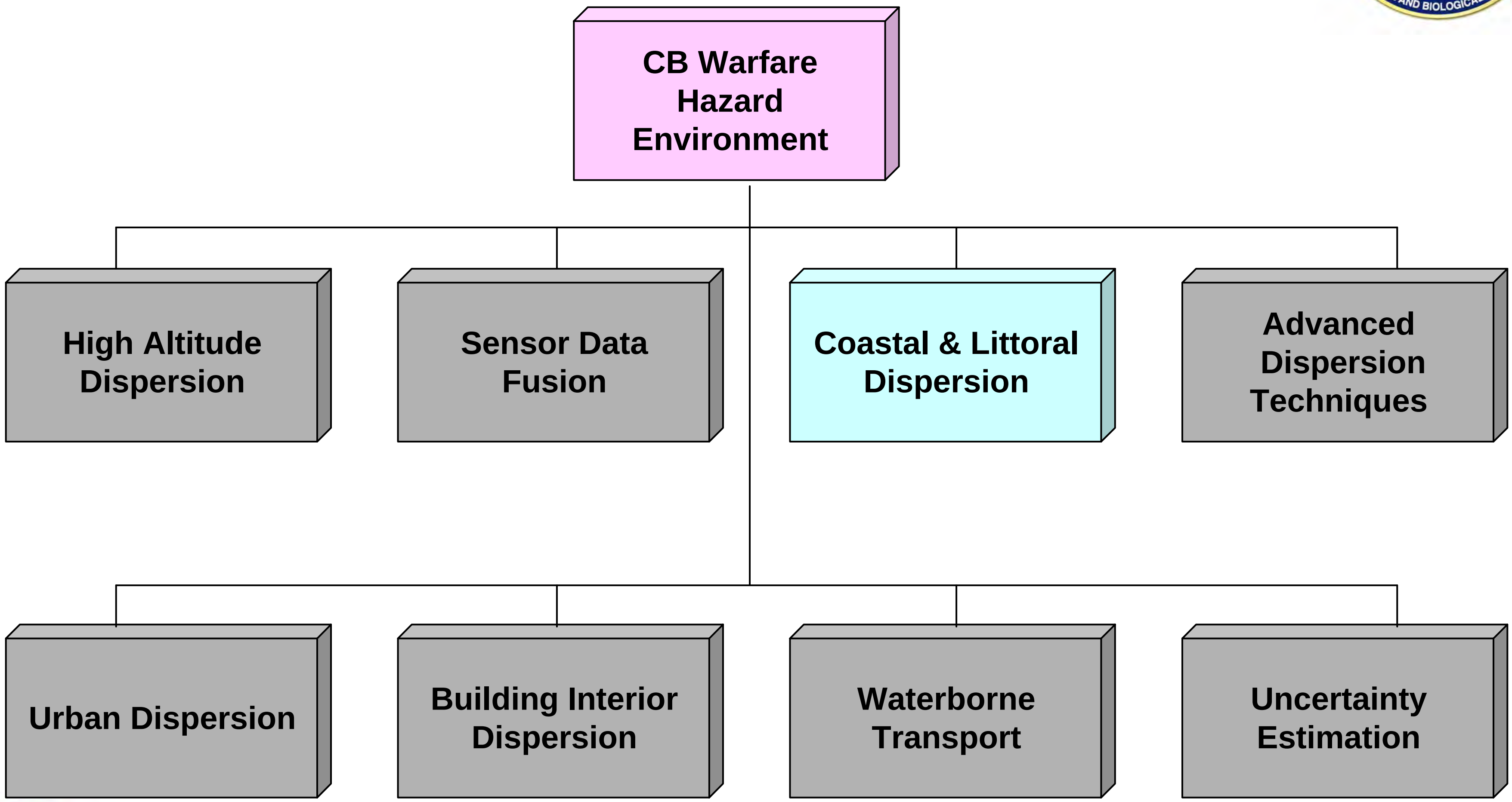
Additional JSTO Sensor Data Fusion Projects

- Sensor Network Methodologies (NSWC Crane)
- Support to JSTO Sensor Data Fusion Program (NOAA)
- Beginning: Sensor Software Placement Suite (NSWC Dahlgren)
- Beginning: SCIPUFF Adjoint Model for Release Source Location from Observational Data (Aerodyne)
- Beginning: Data Assimilation for Chem-Bio Dispersion in the SCIPUFF/HPAC Computing Environment (UB/PSU) (6.1 project)

Sensor Data Fusion Program Concerns

- Need to work toward better integration, coordination between S&T projects
- Not good enough only to work independently
- Collaboration will increase productivity and improve overall capability
- Some duplication is intended in order to explore different approaches to same problem

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas



Coastal and Littoral Improvement

- JEM Block II requirement – also a key problem area
- Identified at least three ways to address this requirement
  - Use high-resolution weather data
  - Develop improved weather modeling and data assimilation systems to use more observations, including radar and other remote sensing, and develop coupled air-sea models
  - Improve boundary layer parameterizations
- JSTO program currently pursuing four C&L initiatives
  - Nowcasting DTO (NRL Monterey) directly relates to this requirement
  - Beginning: *Coupled Air-Sea Modeling for Improved Coastal Urban Dispersion Predictions* (NRL Monterey) (Thursday 1030-1100)
  - Link to radar propagation work, field tests at NSWC, NRL, NPGS. Beginning: *Measurement of Coastal & Littoral Toxic Material Tracer Dispersion* (NSWC Dahlgren) (Thursday 1100-1130)
  - NOAA/Kamada study using AF data from Cape Canaveral to identify sensing systems required for operational improvement, and to evaluate new boundary layer parameterization scheme

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas

- **CB Warfare Hazard Environment**
  - High Altitude Dispersion
  - Sensor Data Fusion
  - Coastal & Littoral Dispersion
  - Advanced Dispersion Techniques
  - Urban Dispersion
  - Building Interior Dispersion
  - Waterborne Transport
  - Uncertainty Estimation

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Improvements in T&D Methodologies

- JEM has Block II requirement to improve T&D methodologies when significant benefits will result
  - Many options: Add new models, improve source term models, improve parameterizations, make better use of weather or land-surface data, etc.
- Current Projects:
  - Developing MESO/RUSTIC as possible future component of JEM: *Chemical and Biological Hazard Environmental Prediction* (NSWC Dahlgren) (Thursday 0900-0930)
  - Supporting R&D in weather data assimilation (NRL Monterey)
- New Projects:
  - 6.1 project with Army Research Lab: Turbulence in the Stable Boundary Layer
  - 6.1 project with NCAR/PSU: Relationship of Boundary Layer Winds to Soil Moisture & Cloud Properties
  - Cellular Automata Exterior Hazard Assessment Tool (NSWC Dahlgren)
  - Modeling the Atmospheric Chemistry of TICs (DTRA)
  - Coastal and Littoral program (discussed earlier)

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CB Warfare Hazard Environment Prediction Thrust Area Focus Areas

- **CB Warfare Hazard Environment**
  - **High Altitude Dispersion**
  - **Sensor Data Fusion**
  - **Coastal & Littoral Dispersion**
  - **Advanced Dispersion Techniques**
  - **Urban Dispersion**
  - **Building Interior Dispersion**
  - **Waterborne Transport**
  - **Uncertainty Estimation**

DTRA

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Urban Dispersion Modeling

- JEM Block II requirement – already many investments elsewhere – relatively little needed by JSTO
- Variety of urban wind and dispersion models available
  - One choice is to link models of difference scales: *Contaminant Transport and Dispersion Modeling in Urban Areas Using Coupled Mesoscale (WRF) and Urban Scale Models (CFD-Urban)* (CFDRC) (Thursday 0930-1000)
  - UWM, UDM integrated into HPAC
  - JSTO is supporting development of MESO/RUSTIC
  - Initial JEM urban models will be selected by JPM-IS
  - Will need ability to predict CB agent concentration and atmospheric pressure on sides of buildings for link to building interior modeling

Urban Dispersion Modeling (cont)

- Program Plans
  - Complete DTO developing MESO/RUSTIC
  - Proposed IPT to evaluate use of CFD models by JEM
- New Projects
  - Benchmark for Computational Modeling of Urban Flows (NRL)
  - Rapid Wind & Pressure Calculations Around Buildings (LANL)
- Field Studies
  - Urban 2000, MUST, Joint Urban 2003 datasets in widespread use
  - Considering future field studies
    - May conduct study to collect and use data from Pripyat, Ukraine (near Chernobyl) (Texas Tech)
    - May participate in field study near Helsinki Finland

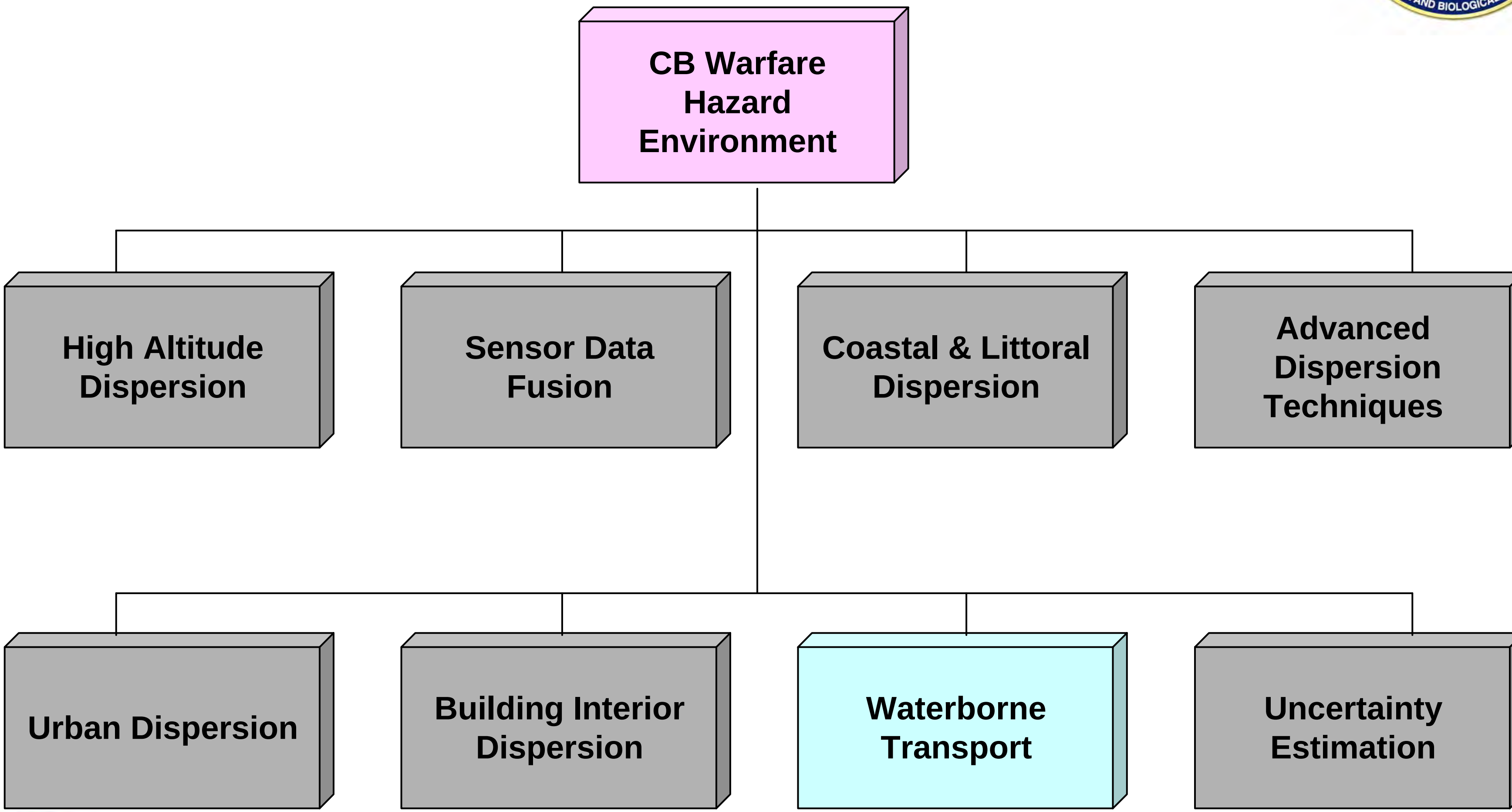
CB Warfare Hazard Environment Prediction Thrust Area Focus Areas

- CB Warfare Hazard Environment
  - High Altitude Dispersion
  - Sensor Data Fusion
  - Coastal & Littoral Dispersion
  - Advanced Dispersion Techniques
  - Urban Dispersion
  - Building Interior Dispersion
  - Waterborne Transport
  - Uncertainty Estimation

Building Interior Dispersion Modeling

- JEM Block III requirement
- Some models already exist
  - Multi-zonal models (COMIS, CONTAM, MBLM) at LBNL, NIST, DTRA, DARPA, NSWC, SAIC
  - Coarse-grid CFD models for large rooms
- Newer types of models may become available
- Proposal to fund coordination of COMIS and CONTAM into next-generation multi-zonal model
  - Leverage DARPA's Immune Building Program, DTRA's BINEX capability, NSWC and DOE/DHS R&D programs
- Hope to coordinate with DHS
  - DHS making large investment in this area

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas

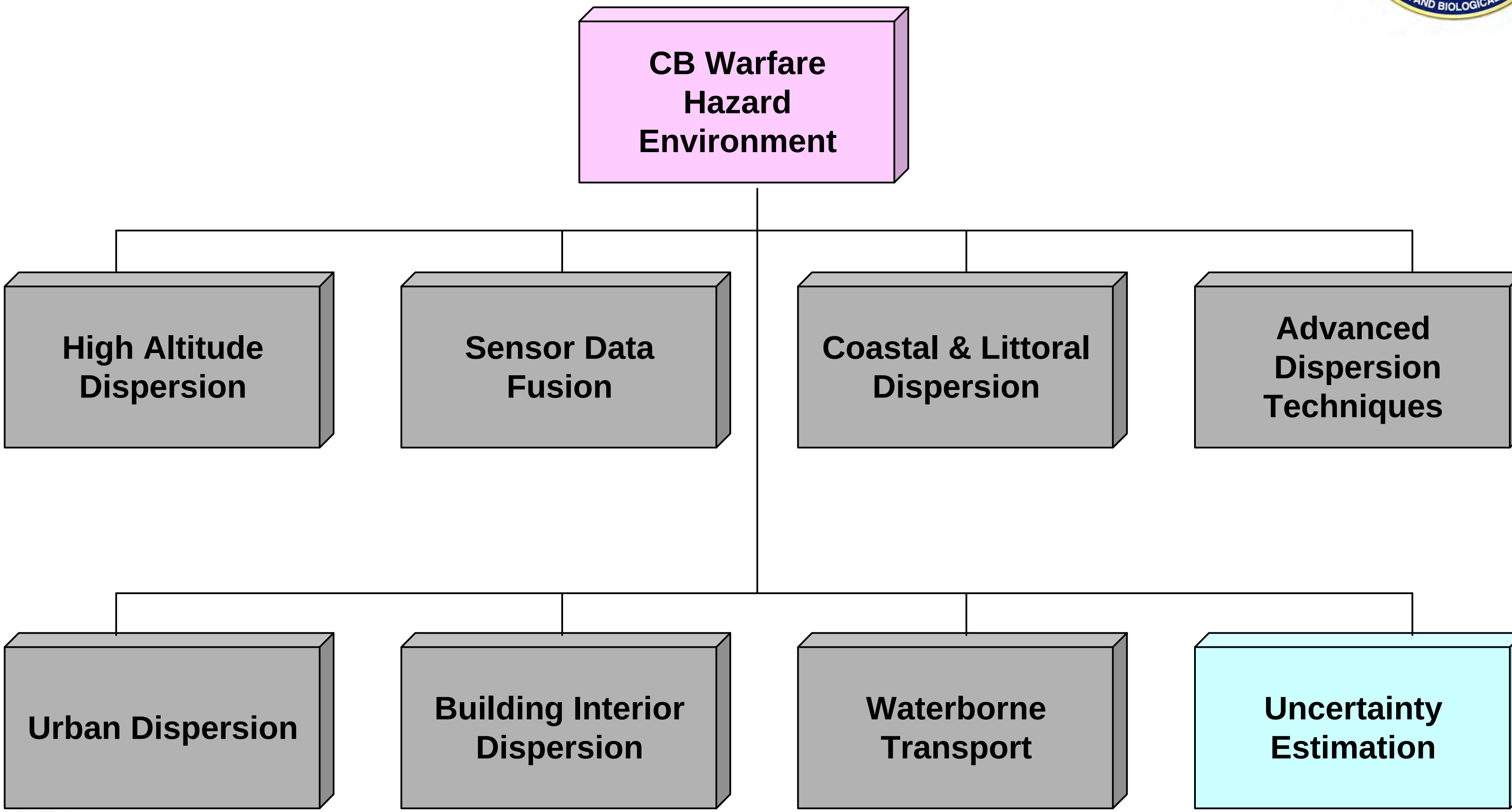


Waterborne Transport Modeling

- JEM Block III requirement
- No active JSTO program in this area now
- Several programs underway elsewhere
  - Navy, ORNL, DTRA, DHS
- JSTO will watch other work and develop programs as needed

- Should we be doing something?

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas



Uncertainty Estimation

- No active JSTO program in this area now

- Should we be doing something?

Performing Organizations

- Previous: NSWC Dahlgren, NRL Monterey, ITT
- Current: NSWC Dahlgren, NRL Monterey, ITT, DTRA, LLNL, UCSB, Dstl, NOAA, NSWC Crane
- Imminent (planned): NSWC Dahlgren, NRL Monterey, ITT, DTRA, LLNL, UCSB, Dstl, NOAA, NSWC Crane, NRL DC, NGIT, NASA, ARL, UB, PSU, NCAR, Aerodyne
- Possible Future: NSWC Dahlgren, NRL Monterey, ITT, DTRA, LLNL, UCSB, Dstl, NOAA, NSWC Crane, NRL DC, NGIT, NASA, ARL, UB, PSU, NCAR, Aerodyne, CFDRC, Titan, ARIA, LBNL, NPS, DPG, DRDC, NIST, DARPA, NASA, AFWA, Titan, ORNL, SAIC, DSTO, TTU, Vaisala…?

Summary

- Established comprehensive program to meet requirements, address weak areas, coordinate activities
- Brings S&T program into line with coordinated, unified model development programs
- Expect to see areas of particular expertise developed at DoD labs, R&D activities
- EPP budget increase provided opportunity to develop comprehensive, coordinated program
  - But – can we keep the money?

Backup Slides

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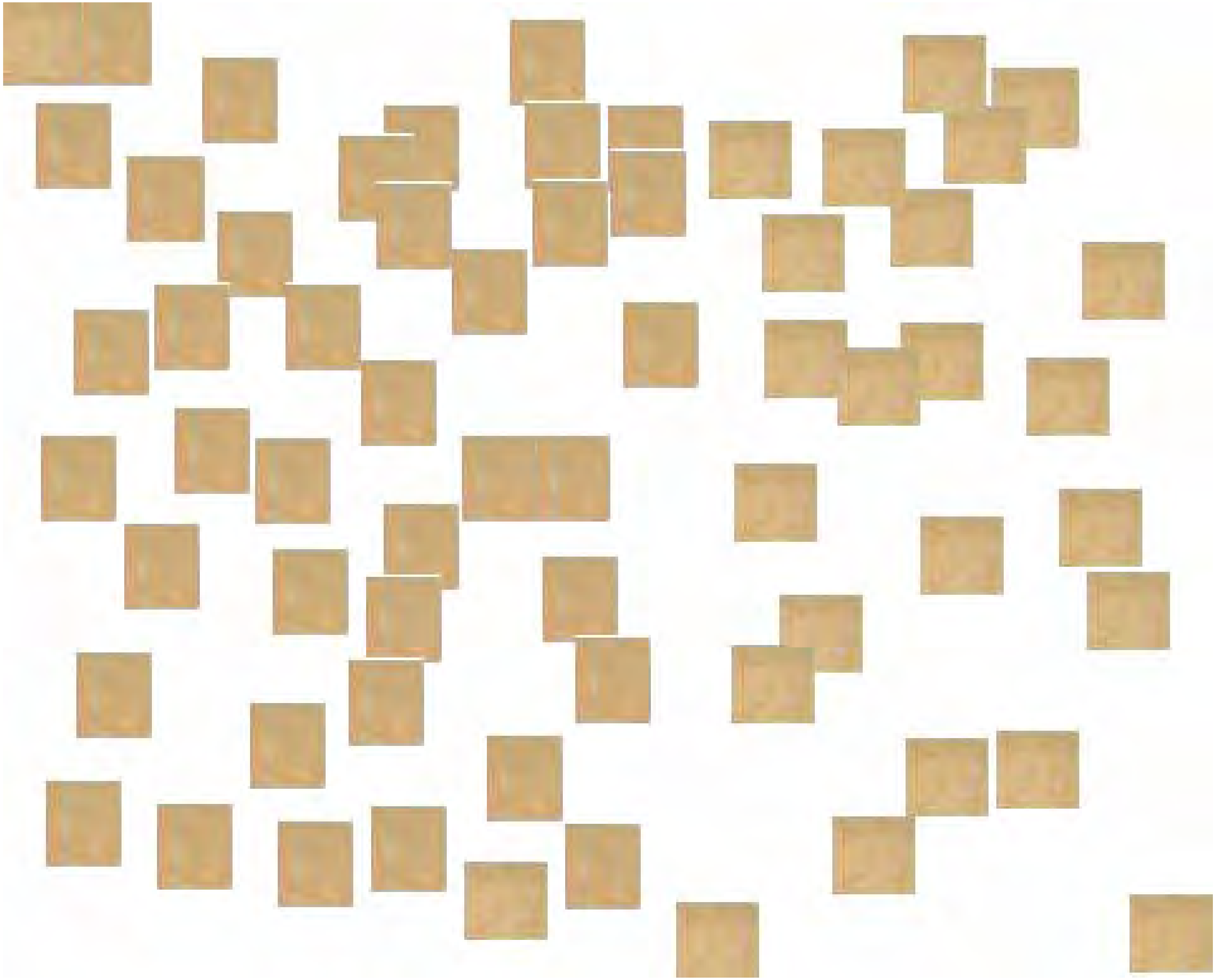
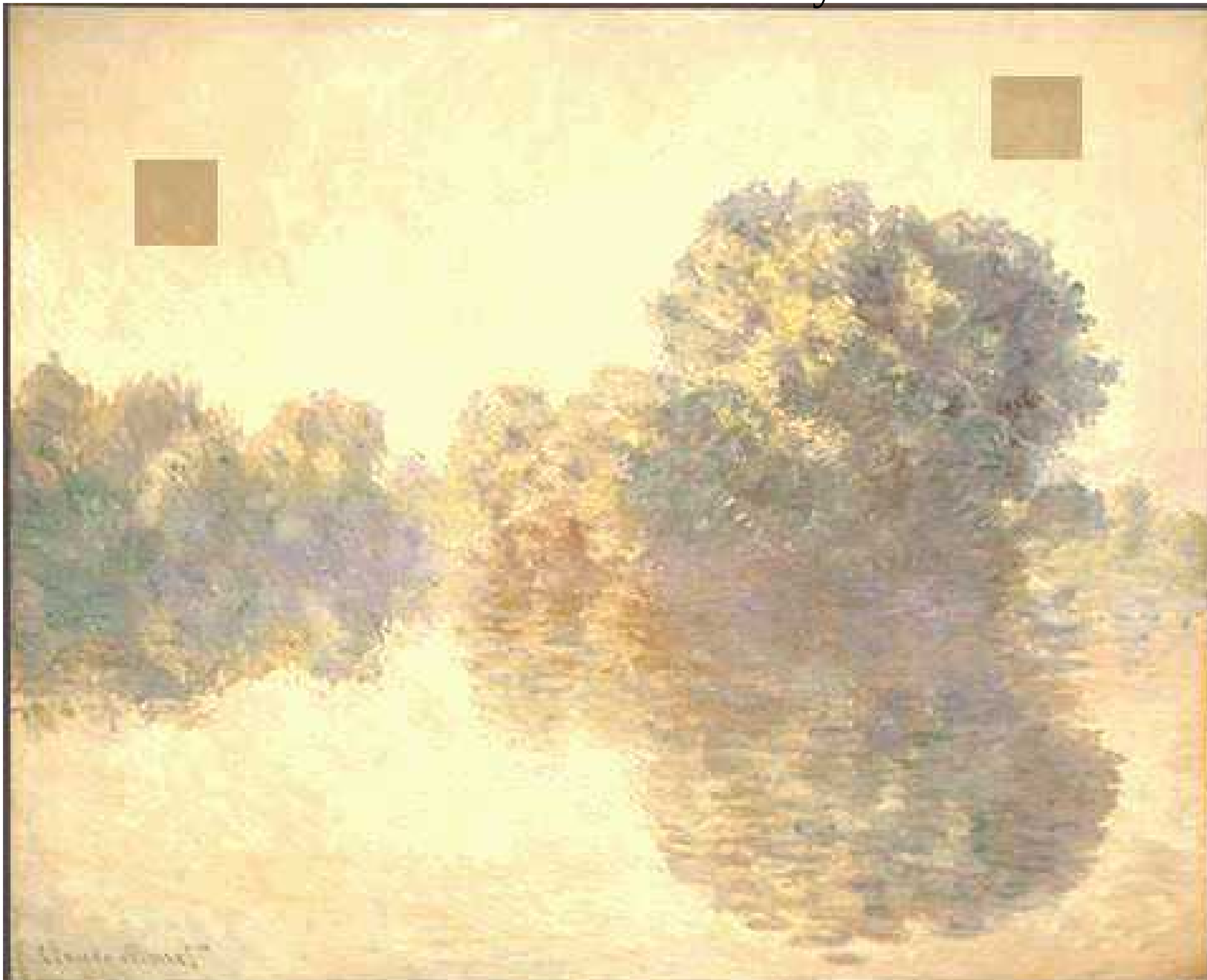
"Model" Results – not perfectly accurate

Sensor Data – provide only snapshots of hazard

Hazard depiction based on interpolation of sensor data



Data fusion? Not really.



Claude Monet ***The Seine at Giverny*, 1897**

Jackson Pollock ***Number 1, 1950 (Lavender Mist)*, 1950**

(The urban problem will be even more complex)

Weather Model Resolution Effects

Coarse-resolution models unable to resolve the sea breeze circulation

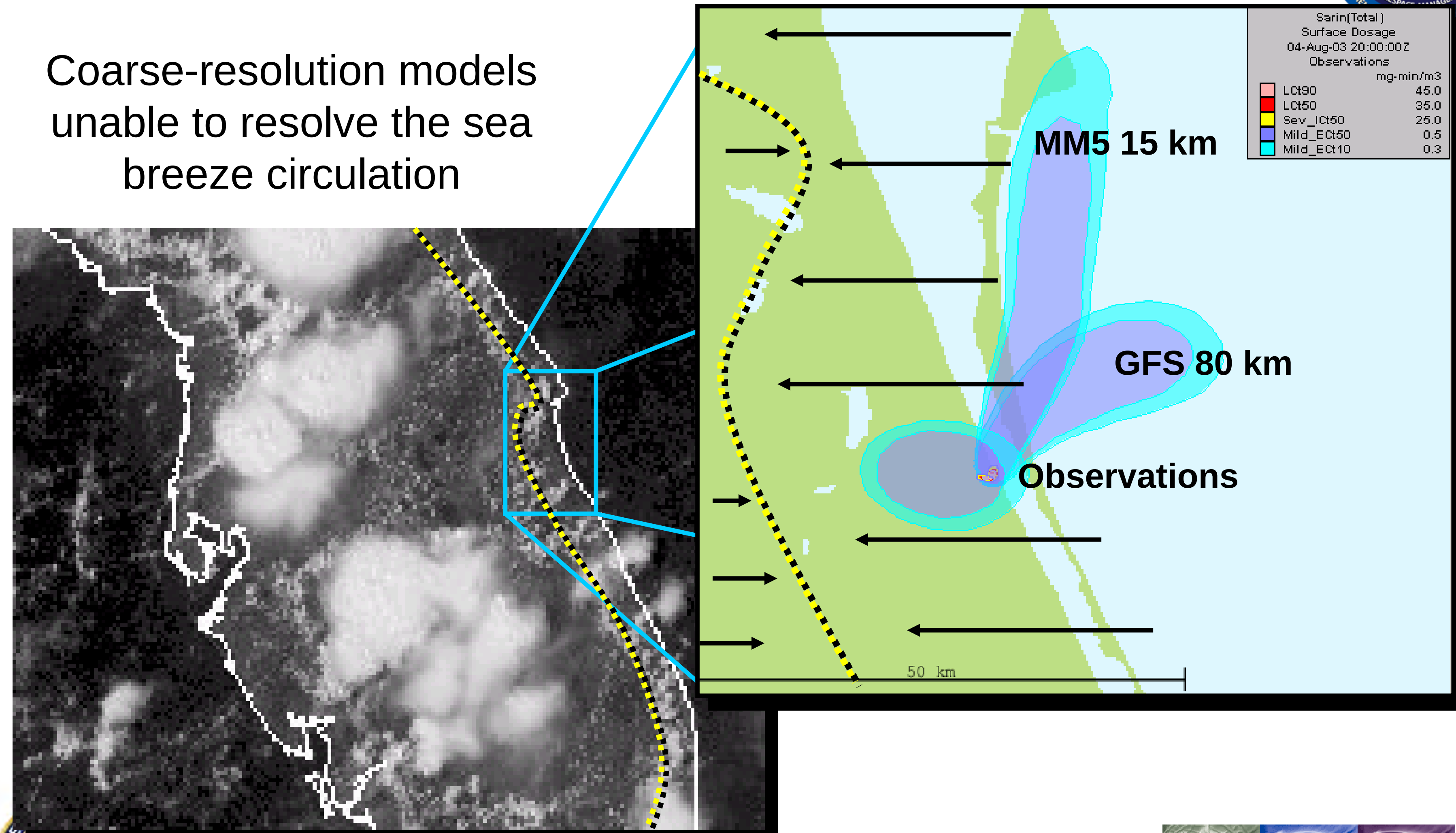


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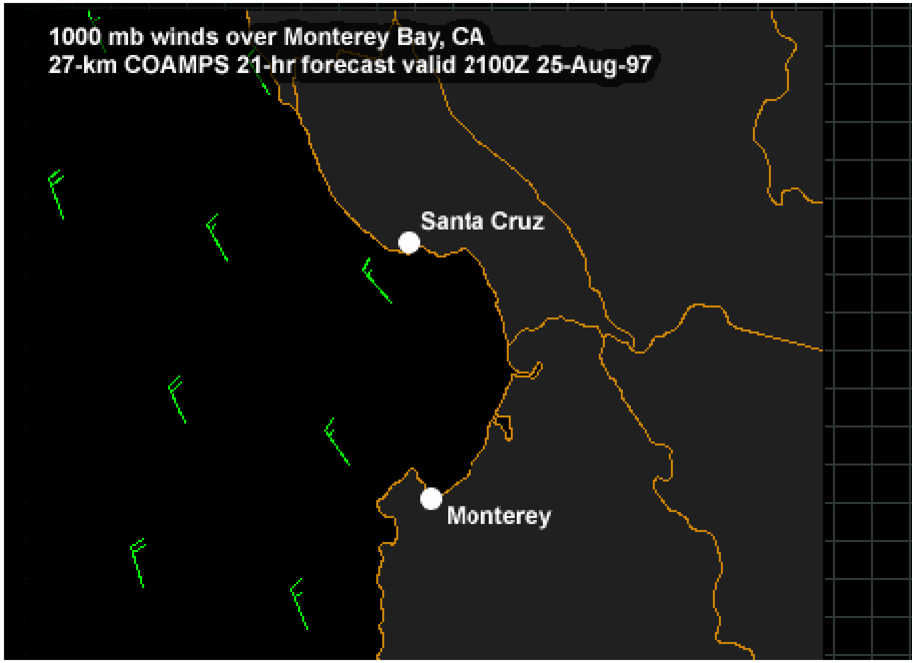
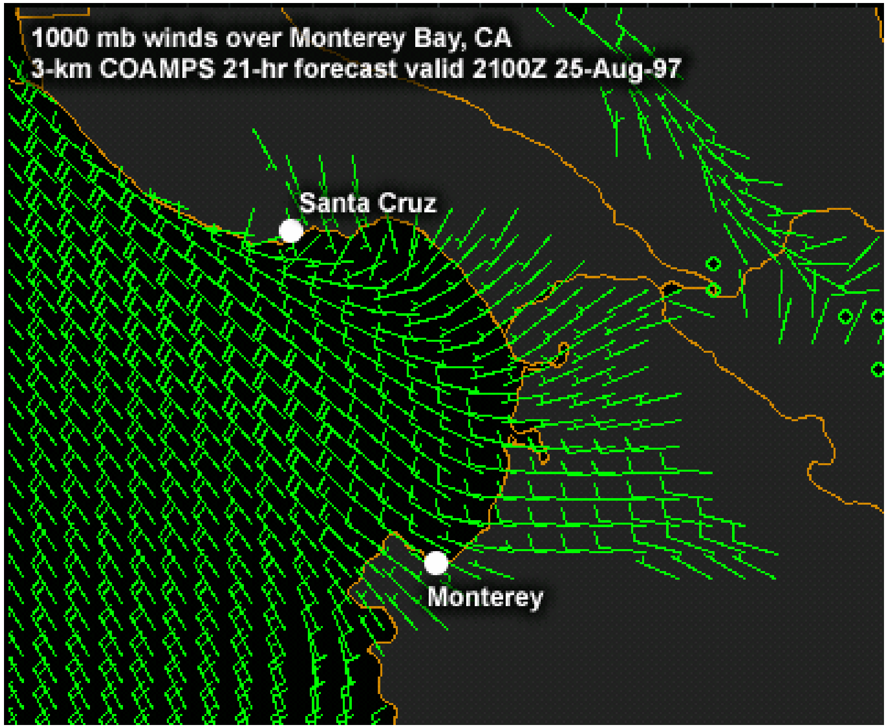
Illustration of Model Resolution Impact



Coarser resolution (27 km) reveals very little detail in the wind field



Higher resolution (3 km) reveals onshore flow of the sea breeze

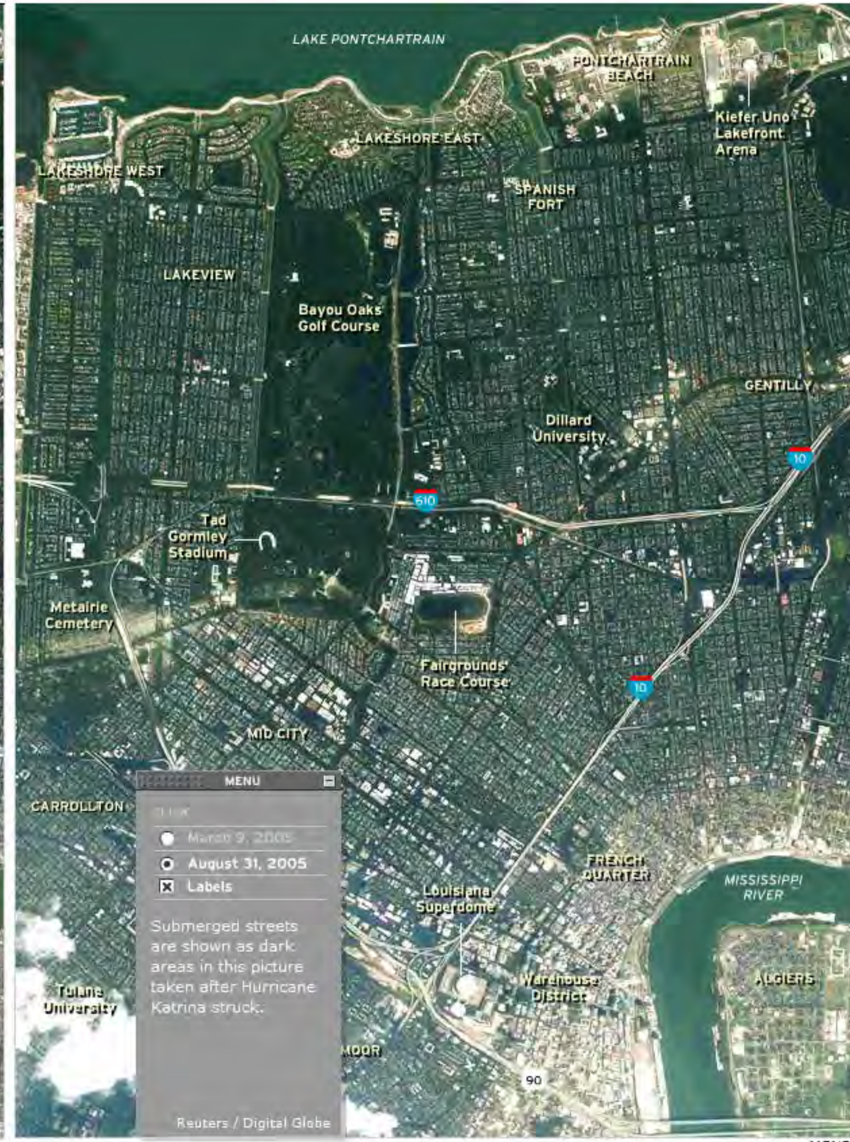
Machine Intelligence in Decision-making (*MInD*)

Automated Generation of *CB* Attack Engagement Scenario Variants

Nadipuram R. Prasad
Arjun S. Rangamani
Timothy J. Ross
M. M. Reda Taha
Frank Gilfeather

BO05MSB070: Multivariate Decision Support Tool for CB Defense
DTRA University Strategic Partnership
Gold Team

New Orleans Scenario



Fundamental Principles

1. Human decision-making is analogous to finding Order within Chaos
2. Order requires Structure
3. Structure requires Rules for preservation
4. Rules must be learned and applied
5. New Rules are discovered as Information (Data) evolves

Order in Scenario Generation

- **Experts match the characteristics of the attacker with postulated attack characteristics to generate engagement scenarios that provide a basis to evaluate the consequences of the attack**

- **Base-Case Variants show the effectiveness of mitigating factors on the consequences including the cost of mitigation**

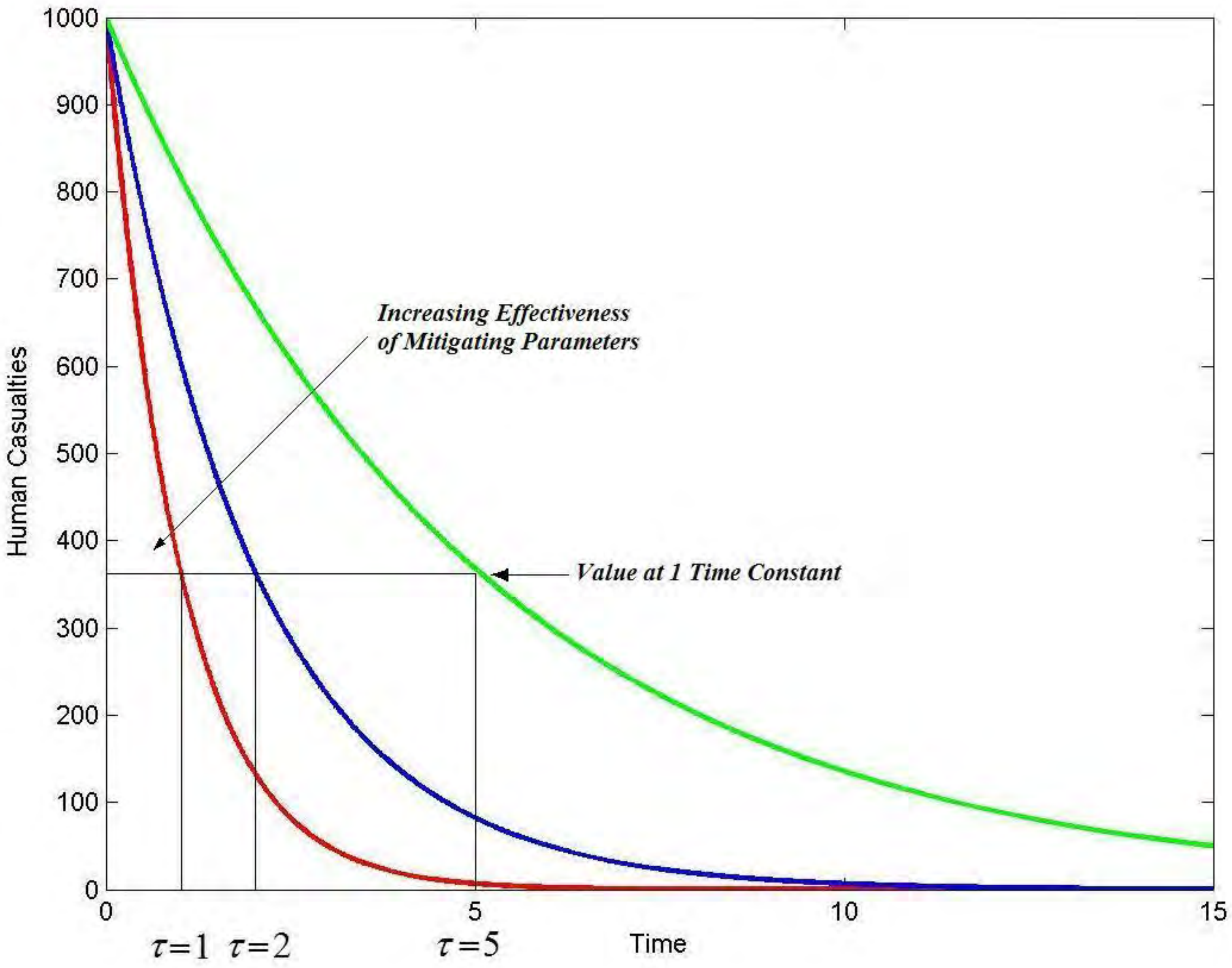
- **The set of Base-Case and Variant exemplars provide the means to develop appropriate cost models that can aid in evaluating S&T funding required to mitigate the consequences**

- **To preserve “order” in scenario variant generation, a set of Rules governing the relationships between the *CB* attack Base-Case and Variant exemplars must be “extracted” and “learned” so that many Variants can be generated for further analysis**

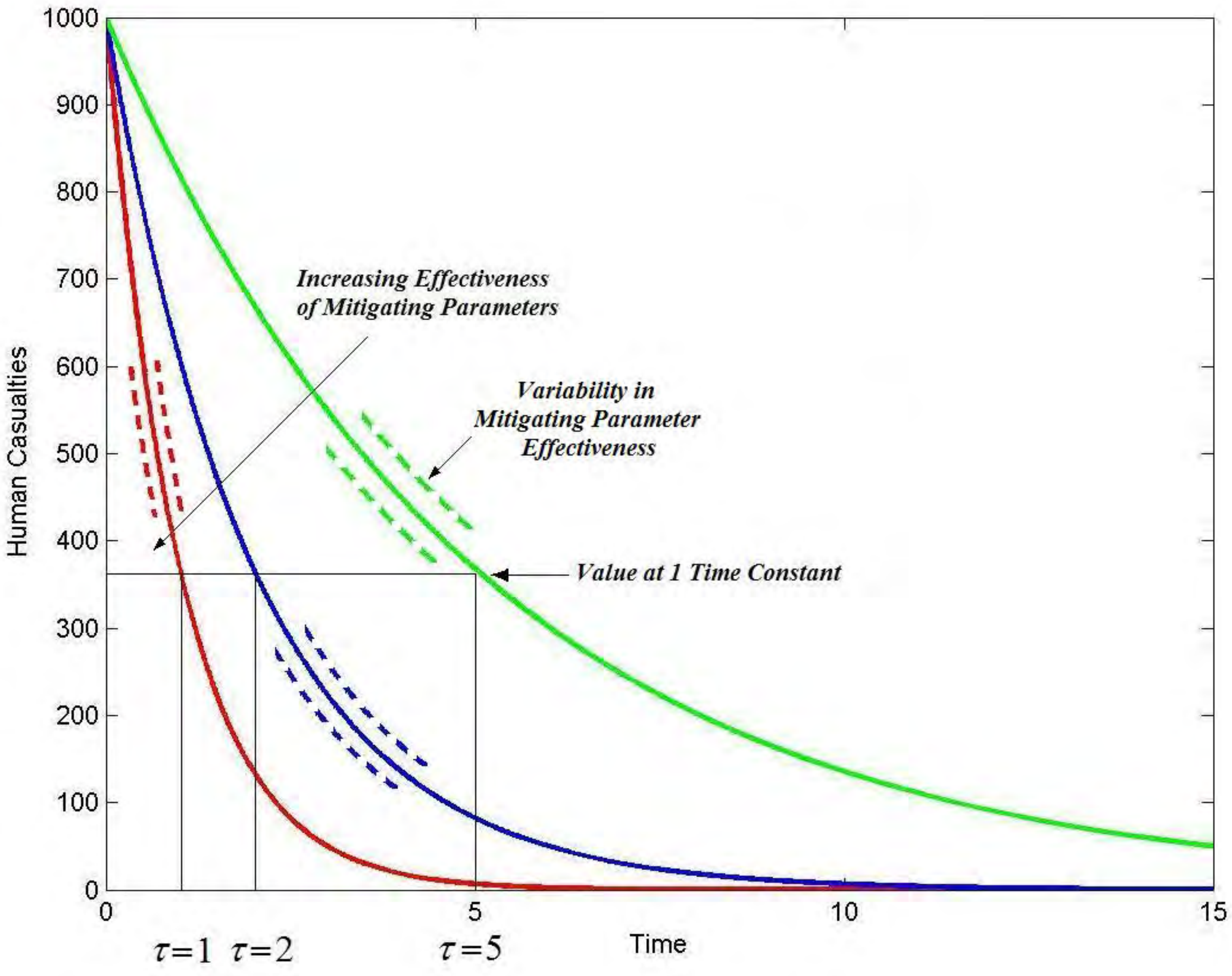
Basis For Automatic Scenario Generation

- Automatic scenario generation is based upon Bose-Einstein's Large Deviation Theory (LDT)
- The fundamental principle of LDT is founded in: "Exponential Asymptotics for Good Sets"
  - What this means is that all sets of new scenario variants must exhibit exponential asymptotic behavior, and satisfy all properties of compact sets

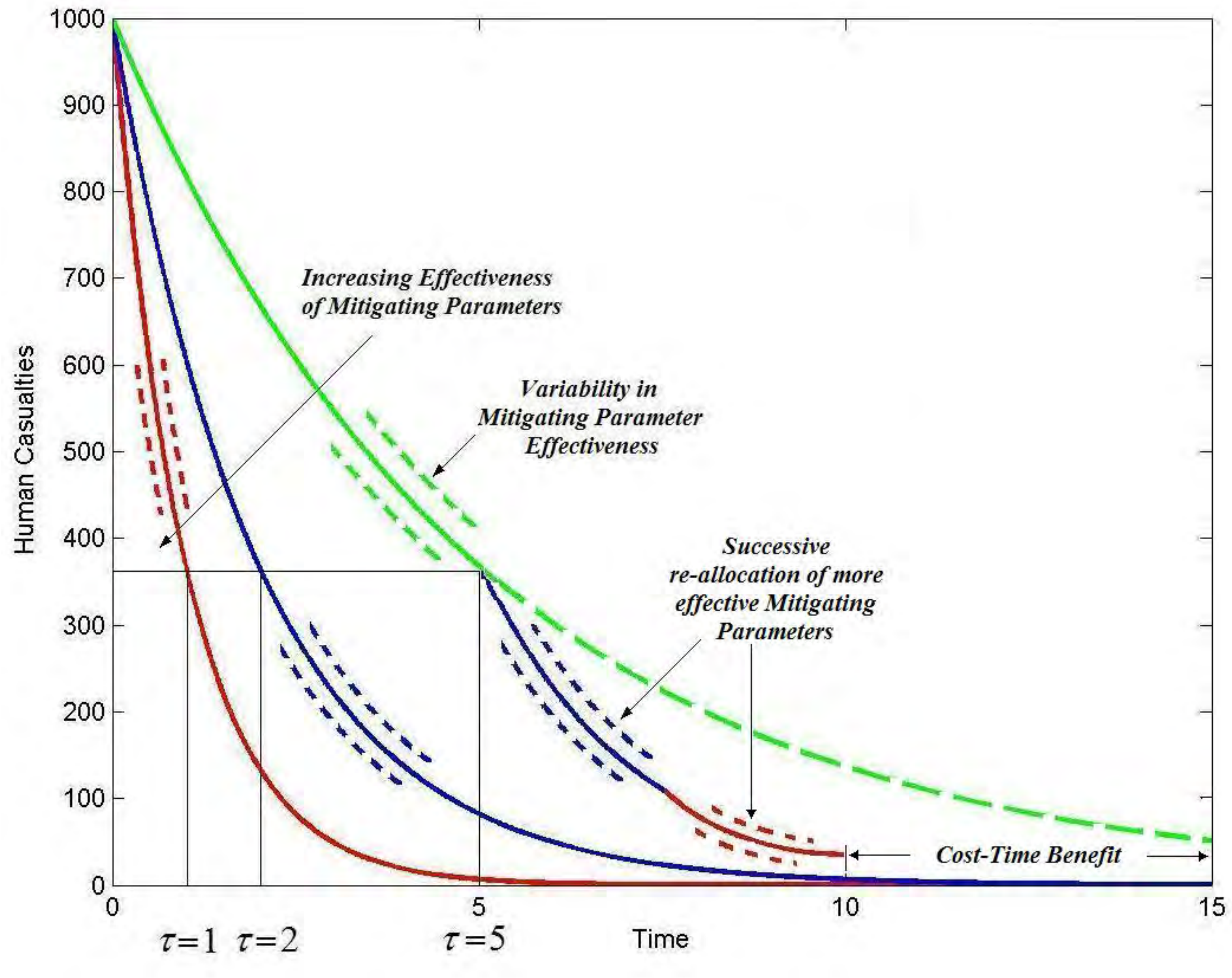
Exponential Asymptotics



Exponential Asymptotics



Exponential Asymptotics



Exemplar Set of Base-Case Engagement Scenario and Variants

PERPETRATORS (X)		Islamist Terrorist Group
MOTIVATIONS (M)		Tactical: Casualties
MILLITARY FACILITIES (T)		Education and Training
CHEMICAL/BIOLOGICAL AGENTS (A)		Sarin (GB) (moderate/high purity)
DISPERSAL MECHANISM (D)		Improvised: Truck
INHERENT CHARACTERISTICS (B)	*Proximity to Civilian Infrastructure*	High
	Air flows	South-Southeast
	Time of Attack	9:00 AM
	Access to Offsite Medical Service(Scale of 0-5)	3
	Access to Civilian Hazmat response(Scale of 0-5)	3

			Iteration 0	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Iteration 6	Iteration 7	Iteration 8	Iteration 9	Iteration 10
CB DEFENSE VARIABLES and SUB-VARIABLES (M)	*Chemical Agent Detectors*	Type of detector.	N/A	C03	C03	C03	C4	C5	C5	C5	C6	C7	C8
		Range of detection (m)	N/A	5000	5000	5000	5500	5500	5500	5500	10000	25000	40000
		Time Taken For Detection (Mins)	N/A	10	10	10	8	8	5	5	5	5	0
		False positive rate(%).	N/A	5	5	5	7	5	5	5	5	0	0
		False negative rate(%).	N/A	3	3	3	7	5	5	5	5	5	5
		No: of sensors.	N/A	3	3	3	3	3	3	3	3	3	3
	Perimeter Protection	Presence of wall/fence.	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
		Presence of barricaded gates.	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
		No: of armed guards.	5	5	15	15	15	15	15	15	15	15	15
	Personal Protection Equipment	Positive Pressure Systems	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO	YES
		Avbl of Masks (%)	0	0	50	50	80	100	100	100	100	100	100
		Avbl of NBC Suits (%)	0	0	50	50	80	100	100	100	100	100	100
		Wearability (Scale of 0-5)	0	0	3	3	3	4	4	4	4	4	5
		% of personnel indoors	80	80	80	80	80	80	80	80	80	80	80
	Trained Onsite Personnel(Scale of 0-5)		1	1	2	4	4	4	4	4	5	5	5
	Chemical Prophylaxis	Type of prophylaxis.	N/A	N/A	N/A	N/A	N/A	PC4	PC5	PC6	PC6	PC6	PC7
		Risk level of side effects.	N/A	N/A	N/A	N/A	N/A	High	Med	Low	Low	Low	Low
		Effectiveness.	N/A	N/A	N/A	N/A	N/A	Med	Med	High	High	High	High
		Max. no: of days safe to take continually.	N/A	N/A	N/A	N/A	N/A	14	60	90	90	90	180
		No: of days before it becomes effective.	N/A	N/A	N/A	N/A	N/A	1	1	1	1	1	1
		Min. no: of days between pre-treatment cycle.	N/A	N/A	N/A	N/A	N/A	30	14	7	7	7	7
		No: of base personnel receiving it under normal conditions(%).	N/A	N/A	N/A	N/A	N/A	10	80	92	92	92	96
	Medical Treatment	Type of medicine.	MT3	MT3	MT3	MT3	MT2	MT4	MT4	MT4	MT4	MT4	MT4
		Effectiveness(Scale of 0-5).	3	3	3	3	5	5	5	5	5	5	5
		Personnel covered by Antidote (%).	0	0	0	100	95	100	100	100	100	100	100
		Capacity to treat (Scale of 0-5)	1	1	2	2	2	3	3	3	4	4	4
IMPACT and COST VARIABLES (C, Cost)	*No: of human casualities*		400-550	400-550	200-250	0-25	100-200	50-75	25-75	0-50	0-25	0-25	0-10
	Remediation costs(in millions of US $)		4	4	2.5	1	2	1	1	1	1	1	1
	No: of days of mission disruption		30	30	30	30	30	30	30	30	30	30	30
	Geo-political impact		High	High	High	Low	Med	Low	Low	Low	Low	Low	Low
	Cost of S&T into CB defensive measures		0	0	0	0	600	750	1750	3000	3400	4000	7500
	Cost of deployment (in millions US $)		0	45	57	907	182	275	525	785	985	1335	1785
	S & T Time (months)		0	0	0	0	60	60	72	96	60	96	120
	Deployment Time (months)		0	12	12	48	24	60	36	36	24	24	36

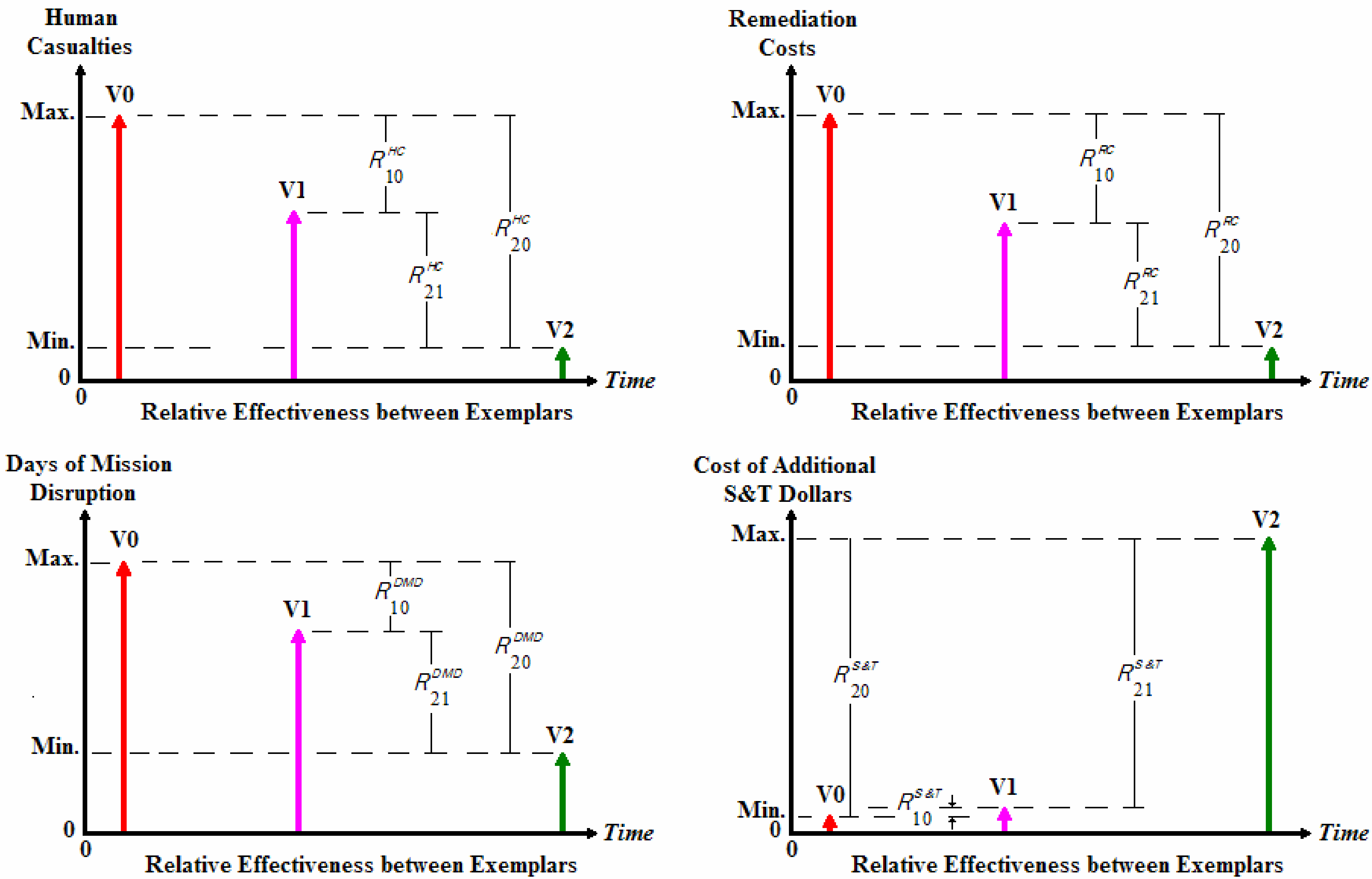
Adaptive Network Fuzzy Inference System (ANFIS)

- ANFIS is a set of fuzzy inference rules written in a neural network structure.
- Rules are extracted from exemplar data and learned.
- The resulting fuzzy-neural structure can be used to identify the effectiveness of mitigating factors on the consequences of *CB* attack scenarios.

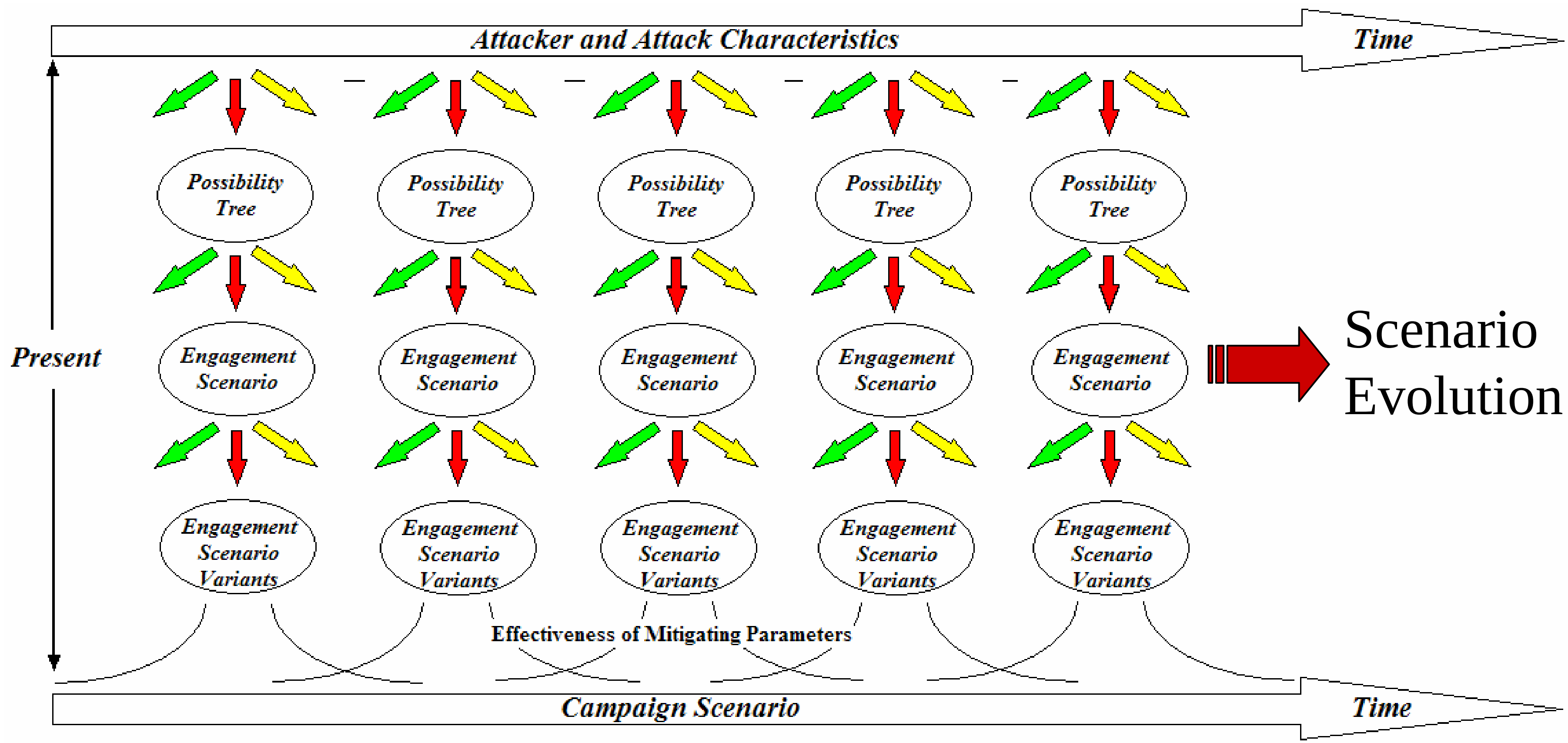
Scenario Variant Generation

- Exemplars of scenarios provided by *CB* Experts are used to train ANFIS rule-based structures and provide the means to generate hundreds and thousands of interpolated scenario variants.
- Large numbers of variants provide the means to Rank the effectiveness of mitigating factors on minimizing the overall consequences, and in identifying the total cost of additional S&T funds required.

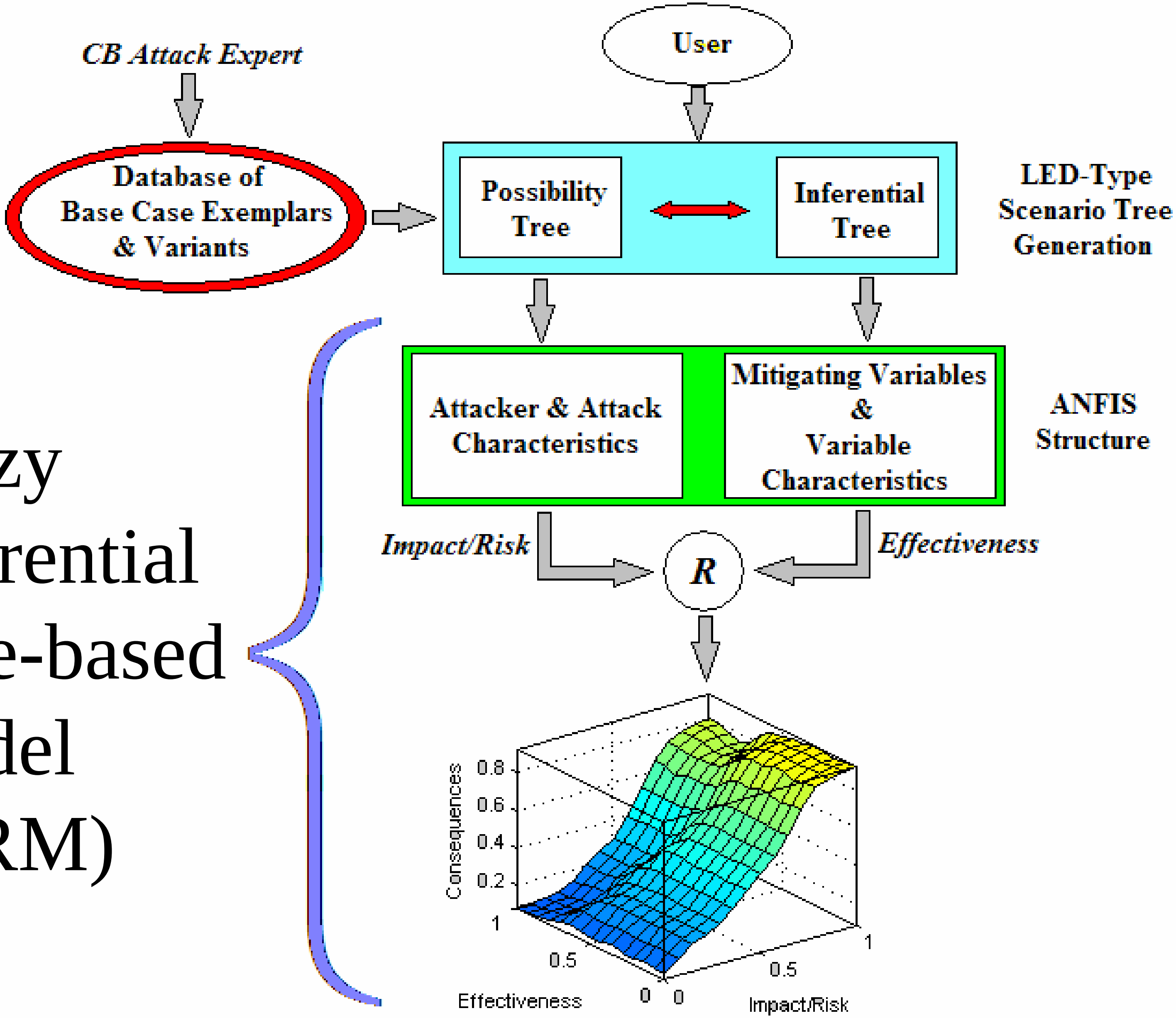
Relative Effectiveness Between Base Case Engagement Scenario and Variants



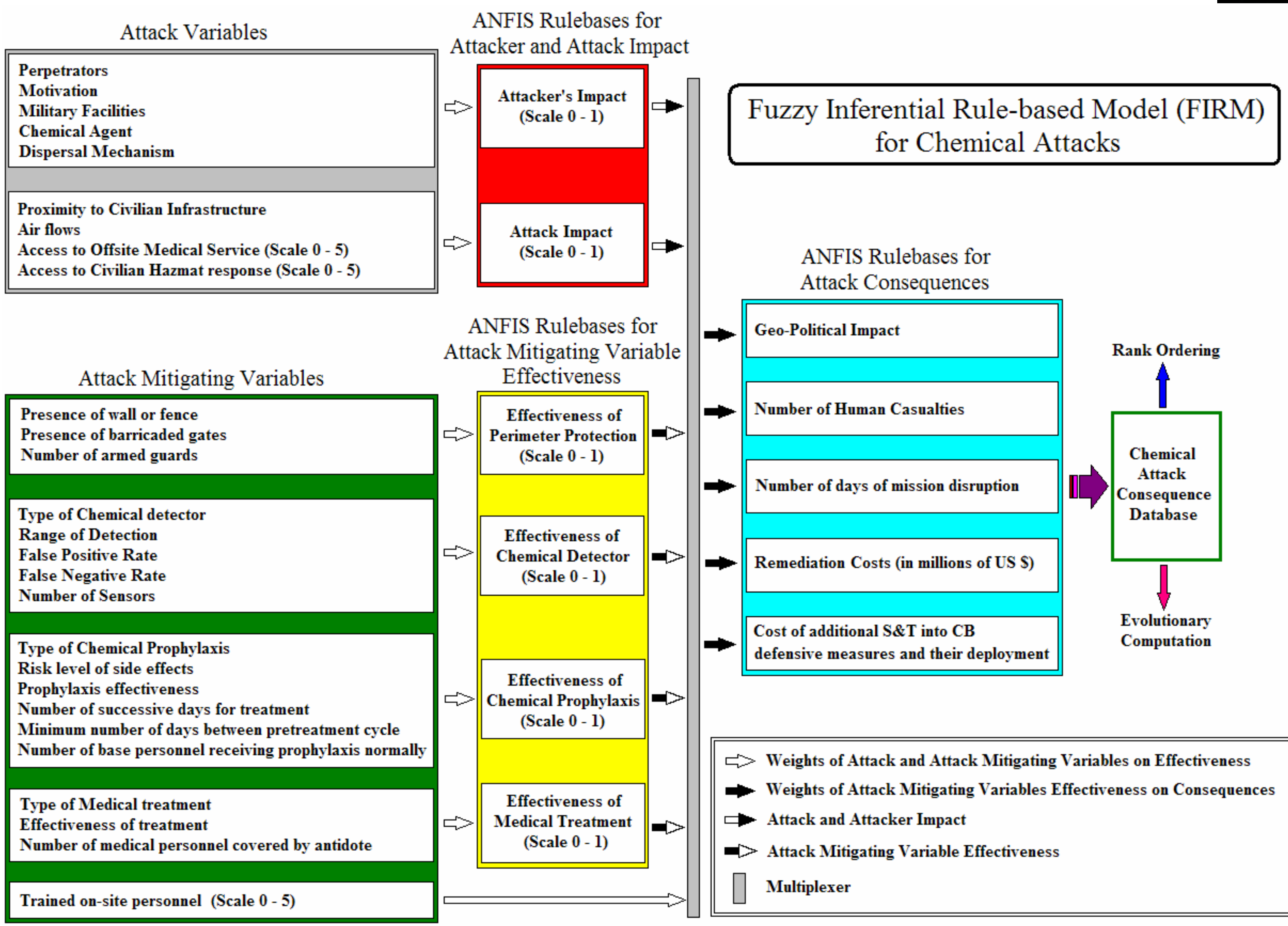
Evolution of Possibility Trees & Engagement Scenario Variants



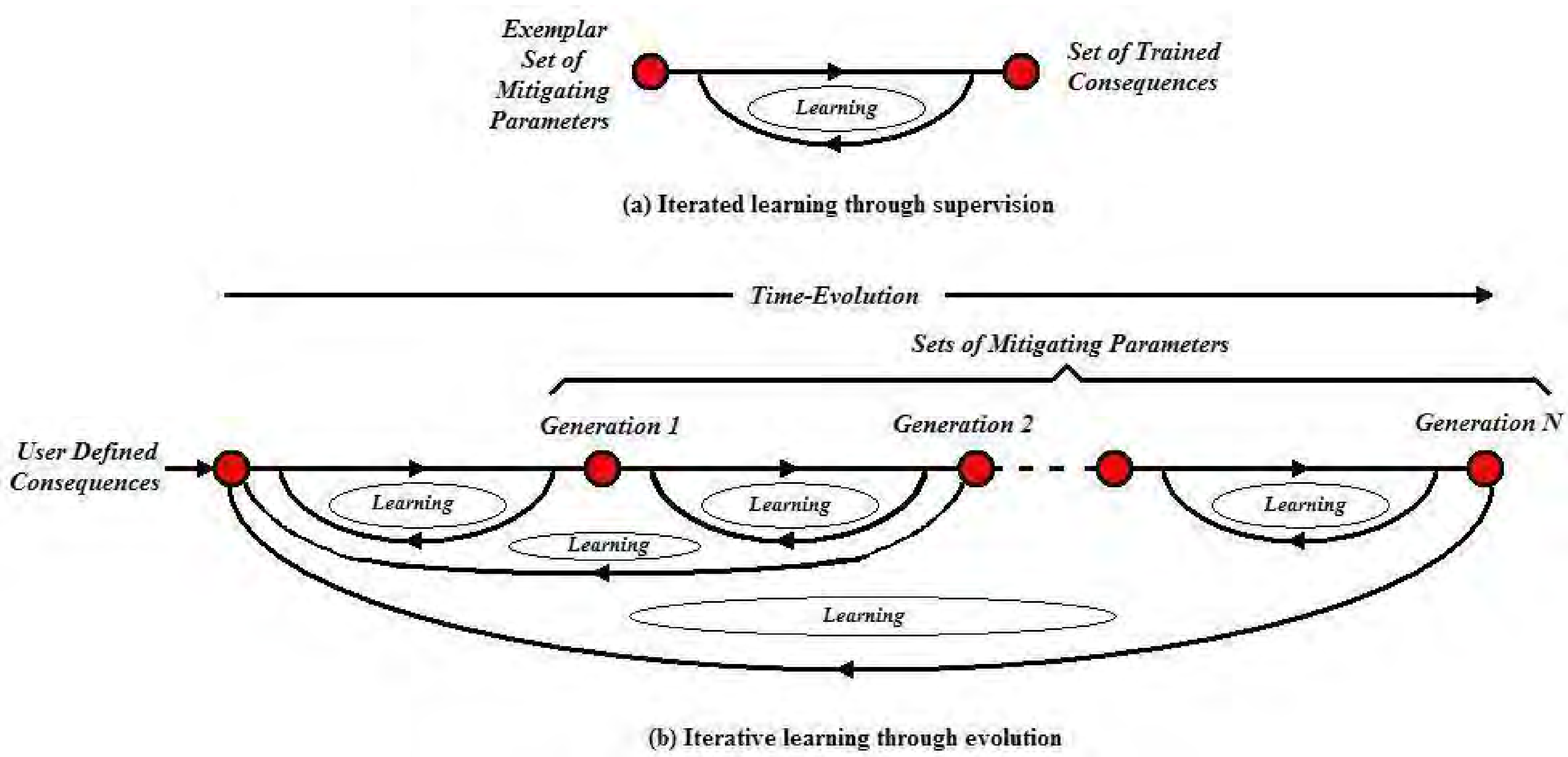
Fuzzy Inferential Rule-based Model (FIRM)



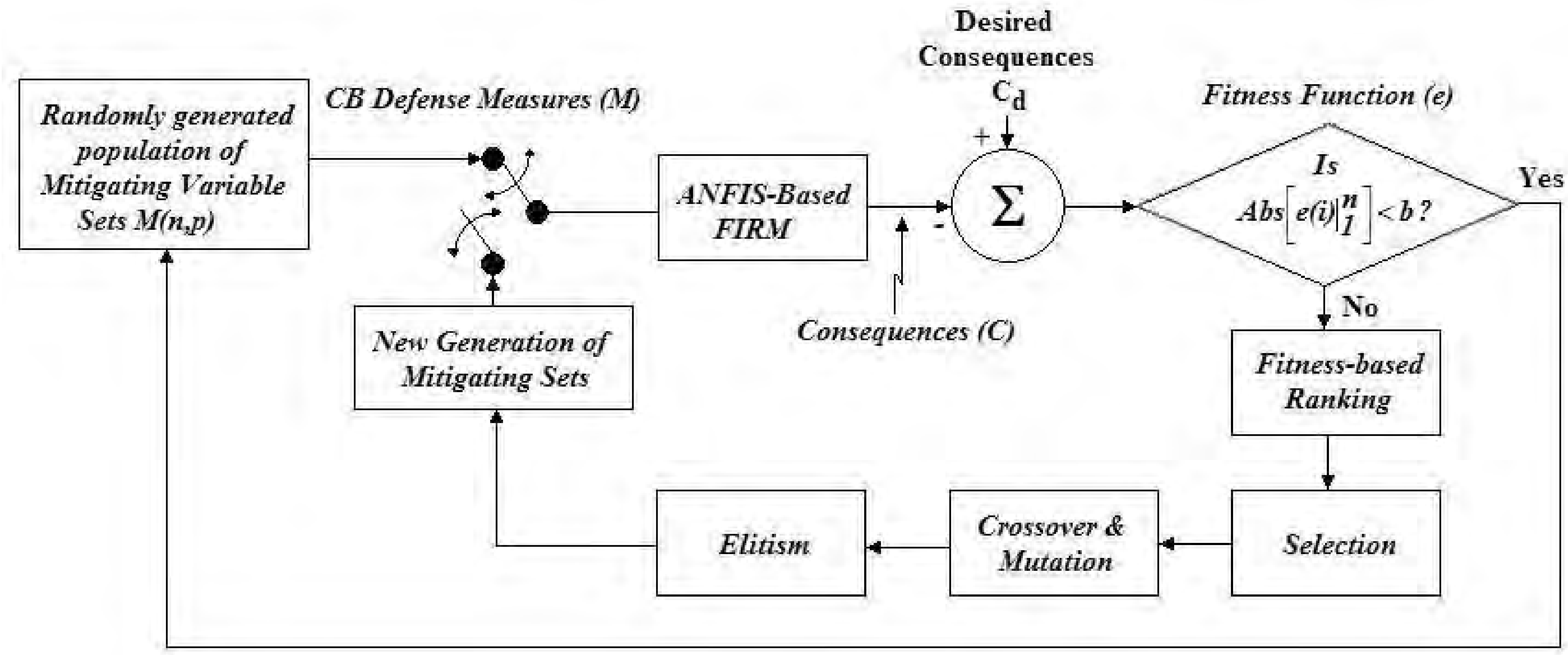
Scenario Variant Generation Using FIRM



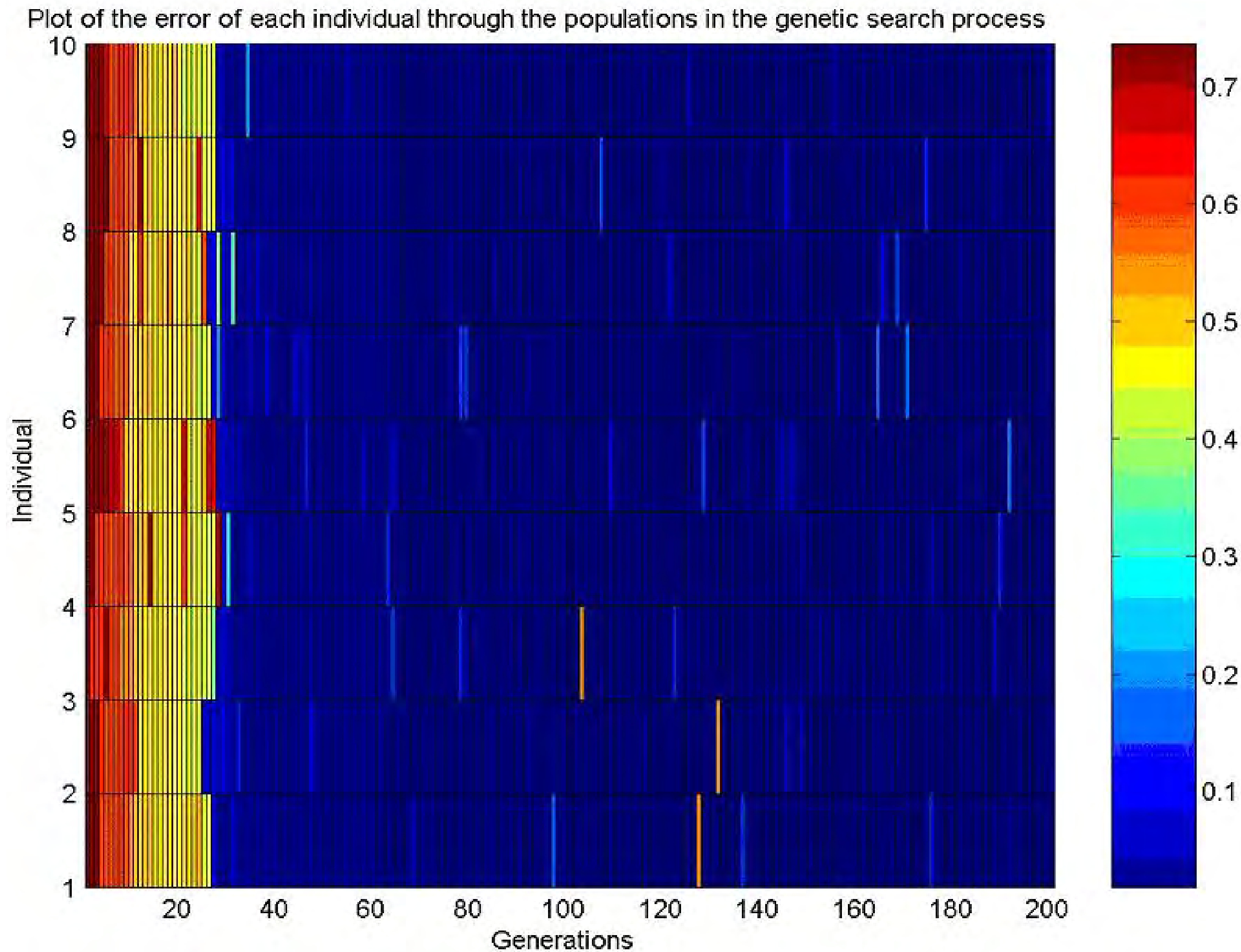
Learning Systems



Evolutionary FIRM (E-FIRM)



Spectrograph of Variant Evolution



Cost Model

$$[\theta_1, \theta_2] = f[\mathrm{Eff}_1, \mathrm{Eff}_2, \mathrm{Eff}_3, \mathrm{Eff}_4, \mathrm{Eff}_5, \mathrm{Eff}_6, t_1, t_2]$$

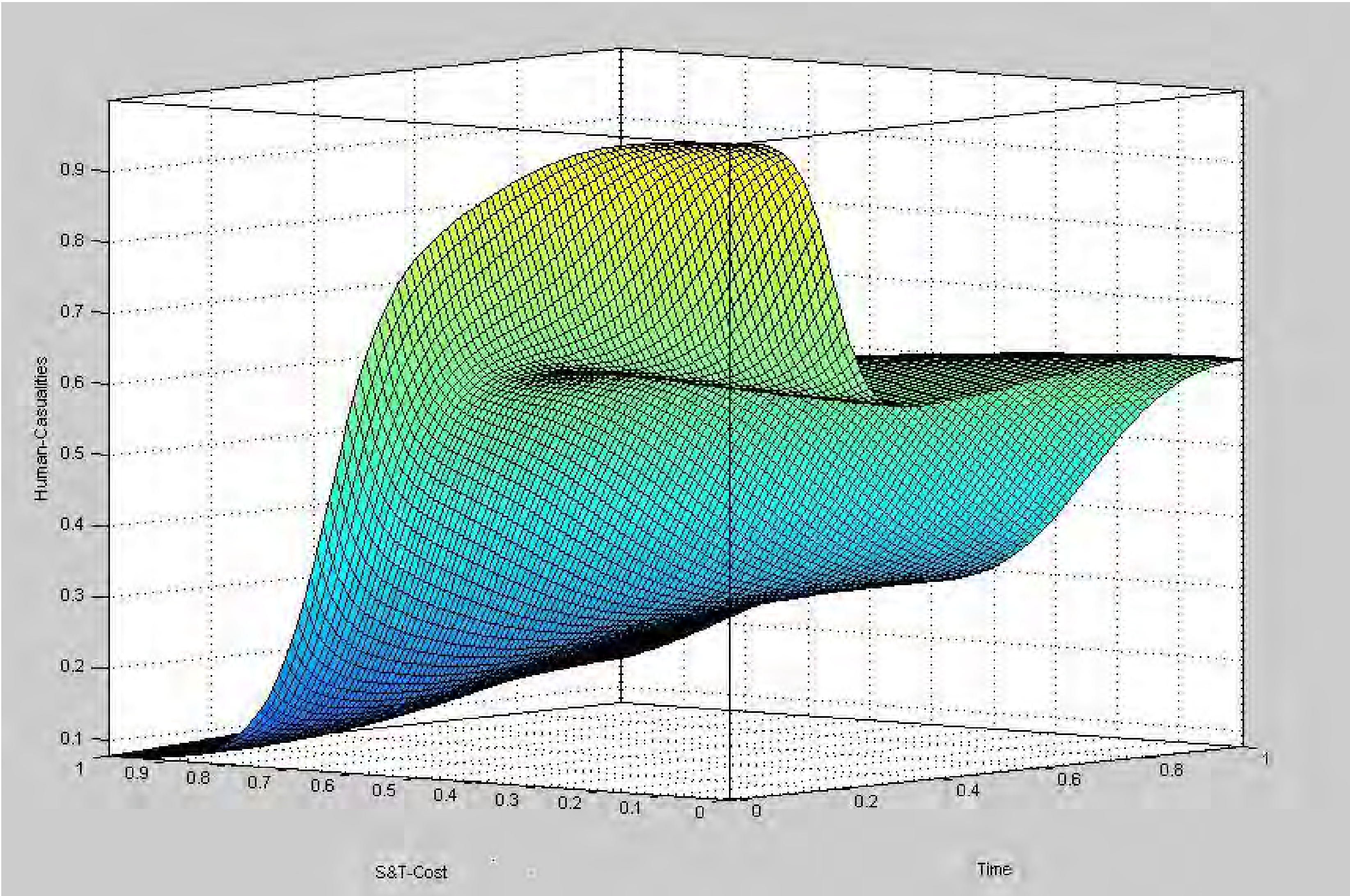
θ_1, θ_2 are the Cost of S & T and the Cost of Deployment

$\mathrm{Eff}_i\big|_{i=1}^{6}$ are the mitigating factor effectiveness

t_1, t_2 are the time required to achieve the desired effectiveness

This is a nonlinear mapping for which a Radial Basis Function Neural Network with dynamic allocation of neurons has been applied

S&T Cost to minimize Human Casualties based solely upon Expert generated Engagement Scenario exemplars



Advances in *CB* Attack Analysis

- It is shown that a "**rule-based**" inferential method with ability to "***learn***" CB attack scenarios and consequences, and "***evolve***", is necessary for machine intelligence in decision-making (*MInD*) where multitudes of scenario variants can be generated on demand
- The structure of *MInD* is explored within an evolutionary framework to emulate Human-like learning and decision making for *CB* attack analysis
- A fuzzy-neural system embedded in the Fuzzy Inferential Rule-based Model (FIRM) exhibits learned decision-making abilities to predict the effectiveness of mitigating factors on consequences

More ……

Advances in *CB* Attack Analysis

- An evolutionary structure (E-FIRM) allows the examination of multitudes of mitigating factor variants using FIRM as a kernel to yield a desired set of consequences
- The evolutionary structure allows the formulation of appropriate neural network-based Cost Models that provide a basis for ranking alternatives and for optimizing on the cost of S&T funding and cost of deployment over the desired time horizons

Q & A

Work supported under
BO05MSB070: Multivariate Decision Support Tool for CB Defense, DTRA University Strategic Partnership, Gold Team

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U.S. Air Force Research Laboratory
Human Effectiveness Directorate
Cooperative Agreement FA8650-05-2-6523

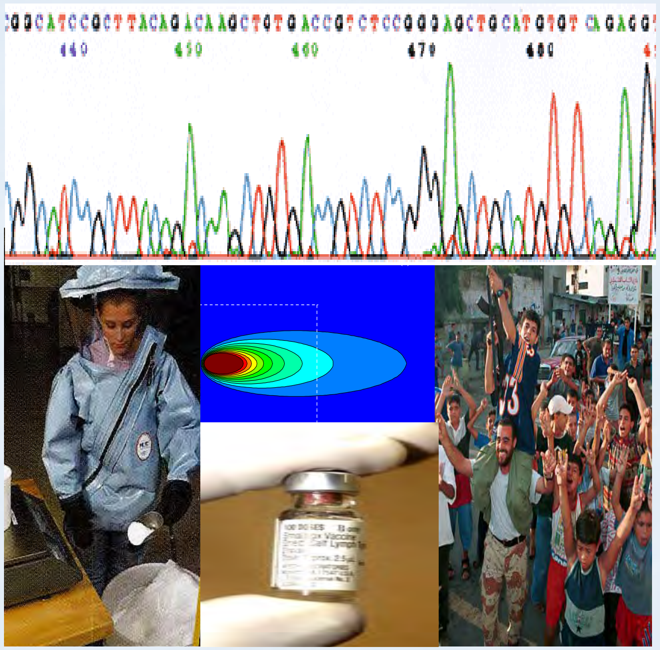
Advances in Biotechnology and the Biosciences for Warfighter Performance and Protection

Dr. Larry Regens
University of Oklahoma Health Sciences Center

Science and Technology for Chem-Bio Information Systems
Albuquerque, NM
25-28 October 2005

The University of Oklahoma
Health Sciences Center

Description of Effort



CENTER FOR BIOSECURITY RESEARCH

- Focus on terrorist attempts to expose humans to aerosol releases of bacterial, viral, and toxin agents

- Project elements designed to expand knowledge, tools, models, and strategies

- Includes international collaboration with scientists in Israel and Russian Federation

Objective

- Support Defense Threat Reduction Agency efforts to advance state-of-the-art in high-visibility area of paramount national importance by enhancing deterrence, detection, preparedness, response, and recovery from CBRNE terrorism

Benefits to Warfighter

- Protect the Nation against terrorism and provide NORTHCOM and CENTCOM capabilities to support national incident response and support US forces fighting terrorism overseas

Engages a Broad-Based Interdisciplinary Team for Research Effort

Projects concentrate on four areas:

- Biomedical Applications
- Threat Characterization
- Consequence Management
- Behavioral Dynamics

CENTER FOR BIOSECURITY RESEARCH

Microbiology

Environmental Health Science

Psychiatry

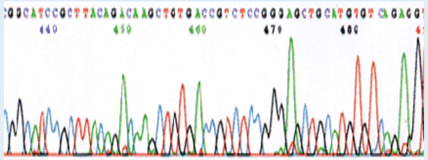
Emergency Medicine

Engineering

Industrial Hygiene

Policy Analysis

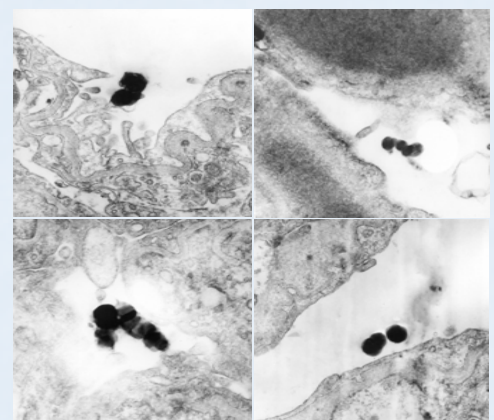
BIOMEDICAL APPLICATIONS



- **Key Challenge: Identify and model cell type-specific, cytotoxic effects and mechanism of lethality**

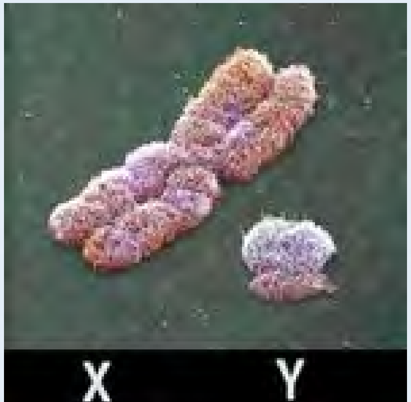
Laboratory Studies to Investigate Cytotoxicity and Immunological Consequences

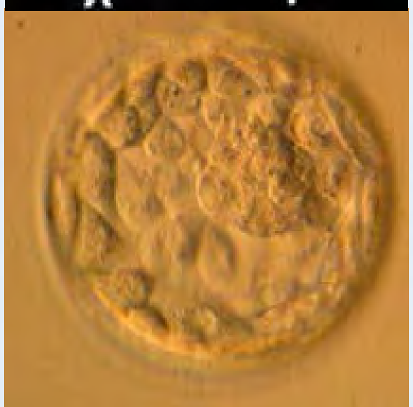
- **Cell and microorganism interactions (microorganism detection and diagnostics)**
- **Immunology (antivirals and immune system stimulants/suppressors)**
- **Therapeutics**



Electron photography of sections of murine lungs with deposited soot particles. Magnification about 20,000.

MAJOR GOALS

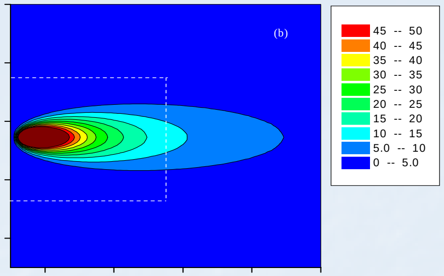


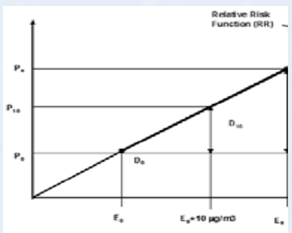


- **Short-Term:** Define molecular and cellular mechanisms of ET-induced cell death for possible development of therapeutics. Most research and therapeutics designed to treat late stage effects of anthrax focus on blocking LT protein complex due to assumption LT is the major virulence factor. Recent OUHSC study has found that ET is cytotoxic to mammalian cells and is more effect killer of cells than LT.

- **Long-Term:** Determine combined effects of ET and LT on cell physiology in order to develop the first comprehensive model of anthrax toxin's collective impact on mammalian cells. Total impact of anthrax toxin on developing embryos will be determined to make predictions about possible birth defects in infants from women exposed to B. anthracis to support diagnosis, vaccines, immunology, and therapeutics.

THREAT CHARACTERIZATION

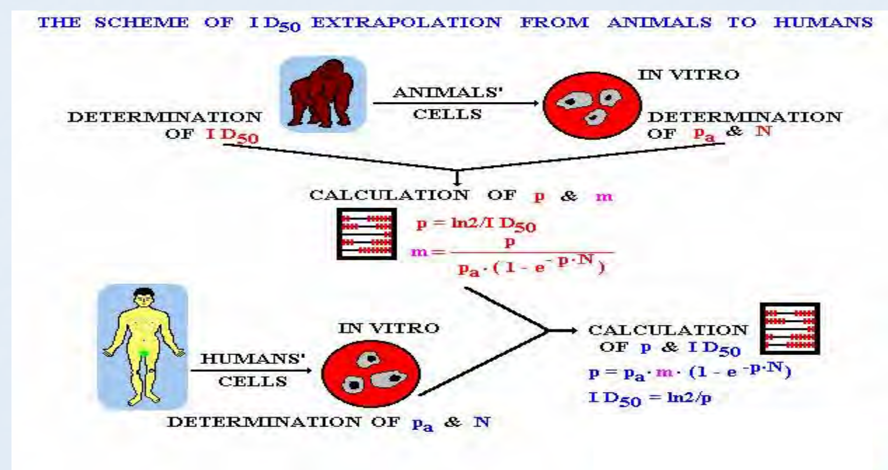




- Key Challenge: Model dispersion, estimate human exposures, and assess risk of aerosol releases for in-door and ambient environments

Modeling and Simulation to Investigate Bioaerosol Dispersion

- Aerosol propagation (direct, inverse, statistical)
- Methods for aerosol sampling and detection
- Measurement of particle deposition in respiratory tract



Posterior View

Left Side

Prototype Computer Model of Tracheobronchial Portion of Male Respiratory Tract

MAJOR GOALS

- **Short-Term: Develop integrated develop computational fluid dynamic (CFD) predictive models of B. anthracis spore inhalation, transport, and deposition for physiologically accurate 3-dimensional representation of adult male, adult female, and child respiratory tract.**

- **Long-Term: Verify predictive models via laboratory experiments with representative simulants and morphologically accurate human respiratory tract airway replicas to support differential exposure-risk assessment. Exposure-dose curves for pulmonary deposition of B. anthracis spores in adult males, adult females, and young children under physiologically realistic breathing conditions will provide basis for infection risk assessment for various exposure scenarios and enable more effective consequence management.**

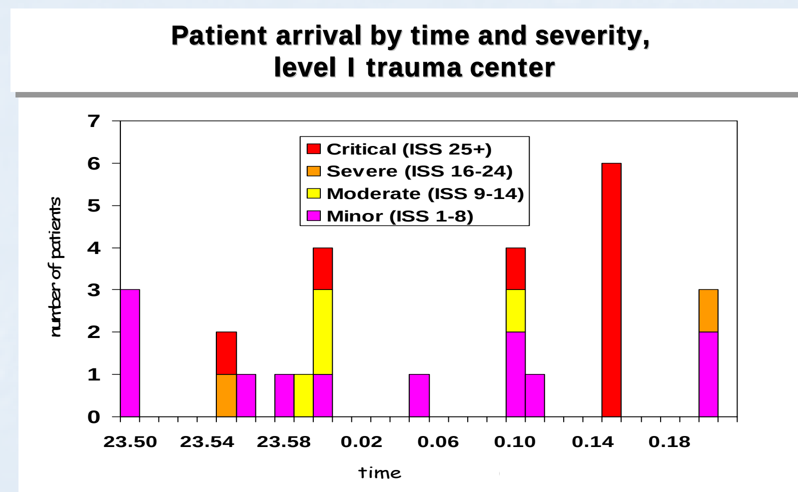
The University of Oklahoma Health Sciences Center

CONSEQUENCE MANAGEMENT

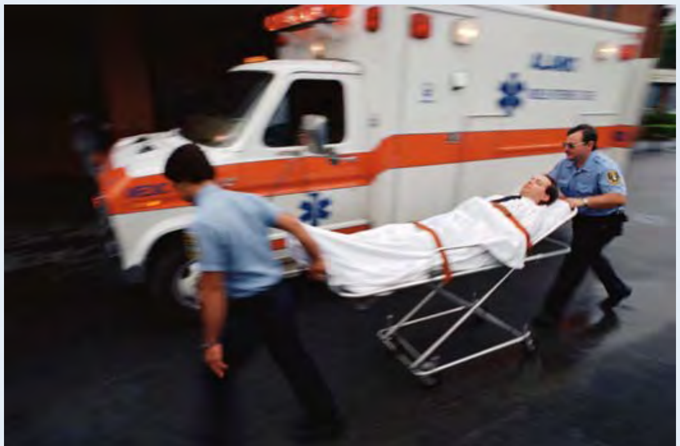
■ **Key Challenge: Delineate information requirements and knowledge transfer mechanisms for effective emergency medical systems**

Investigate Strategies for Effective Preparedness and Response

- **Models of system capabilities for mass casualty incidents**
- **Predictors of response**
- **Lessons learned from prior incidents to enhance resilience**
- **Collaboration with Israel National Center for Trauma and Emergency Medicine Research**



Israel National Center for Trauma and Emergency Medicine Research, Gertner Institute

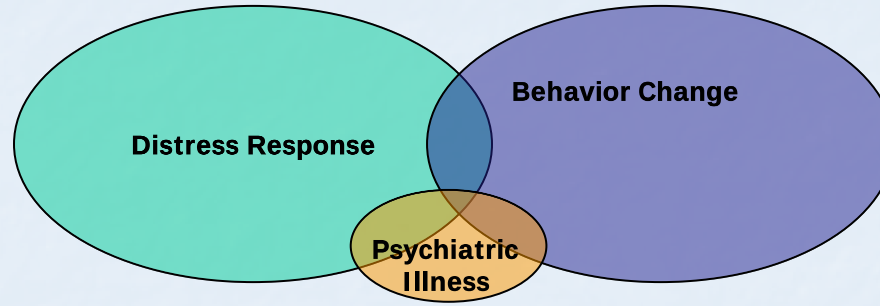


MAJOR GOALS

- **Short-Term: Define key elements in emergency medical response to pediatric mass trauma events utilizing data from Israeli experience. Current US practice is direct transport to hospitals for triage and treatment.**

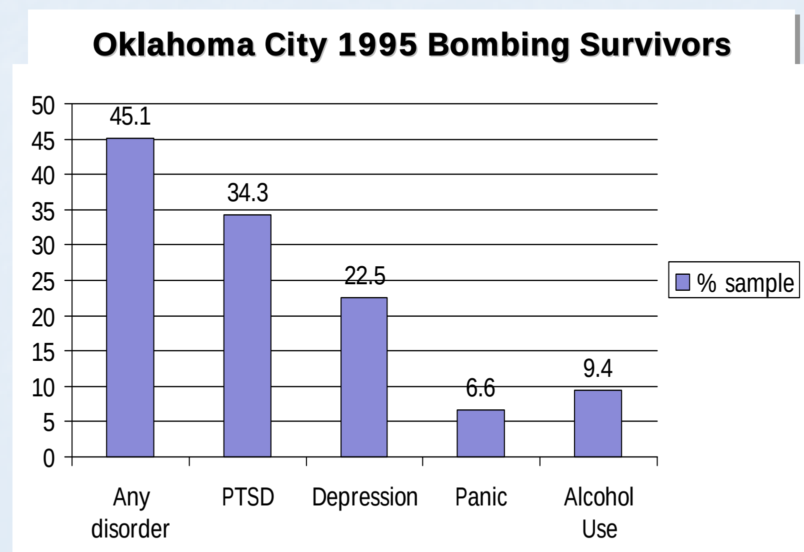
- **Long-Term: Determine applicability of mass trauma experience for bioterrorism mass casualty events in order to develop integrated model of pediatric mass casualty management strategies in the event of exposure to bacterial, viral, or toxin pathogens used by terrorists.**

BEHAVIORAL DYNAMICS

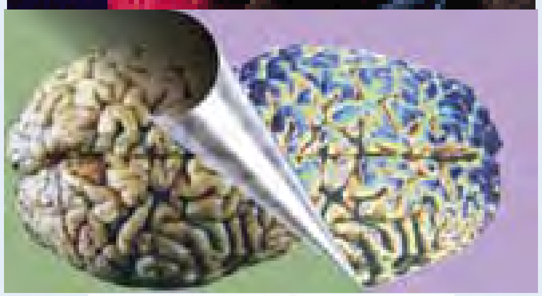


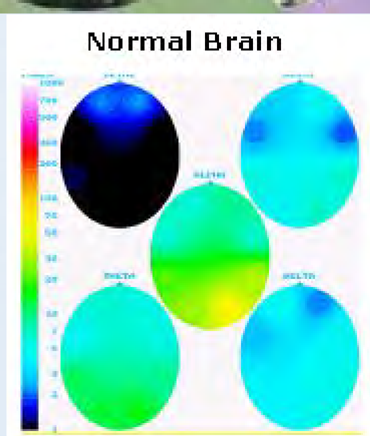
Investigate Psychological Consequences

- Emotional, Behavioral, and Cognitive Effects (distress responses, behavioral changes, and psychiatric illness)
- Predictors of Response
- Recovery Environment
- Resilience



North et al. 1999





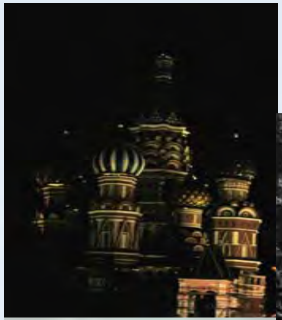
MAJOR GOALS

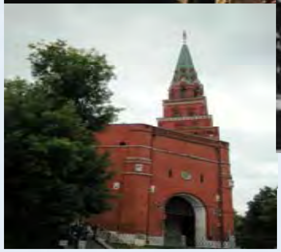
- **Key Challenge: Assess impact of behavioral dynamics on terrorist actions and response to terrorism**

- **Short-Term: Apply attack-oriented analysis to identify which pathogens are of interest for bioterrorism. Identify emotional and behavioral issues specific to bioterrorism.**

- **Long-Term: Develop models for incorporating prevention and intervention approaches to emotional and behavioral health. Evaluate behavioral dynamics of terrorism to enhance counter measures.**

INTERNATIONAL COLLABORATION: RUSSIA





Key Challenge: Developing effective research collaboration on projects with scientists in Russian bioresearch institutes to reduce the threat of bioterrorism and proliferation

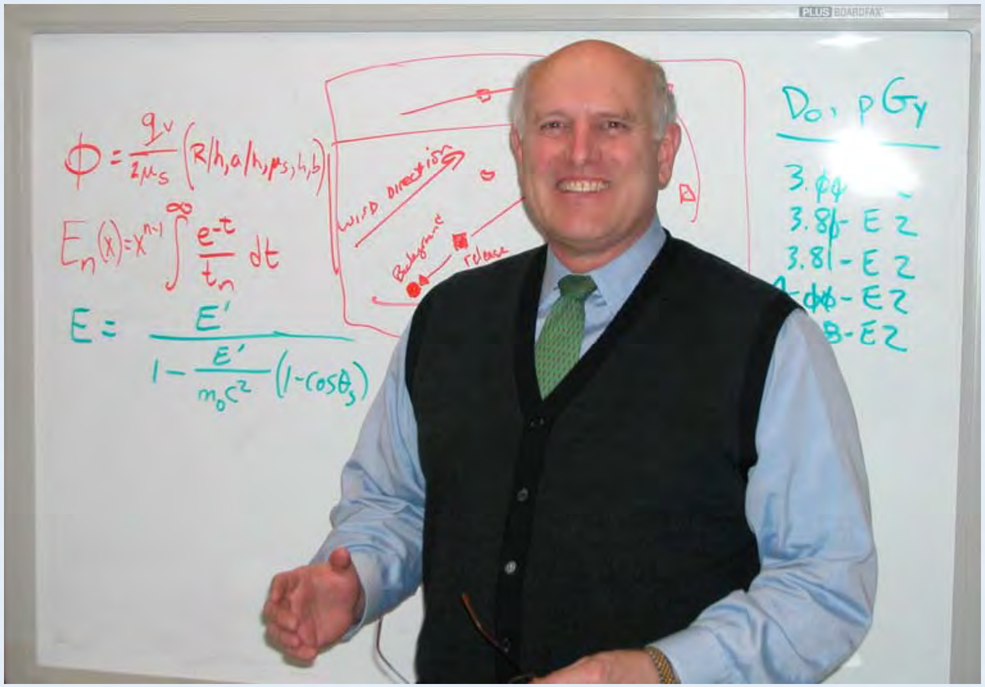
Established Contacts:

- State Research Center for Virology and Biotechnology "VEKTOR" (Koltsovo)
- State Research Center for Applied Microbiology (Obolensk)
- Institute of Immunological Engineering (Lubuchany)
- Gamaleya Research Institute for Epidemiology and Microbiology RAMS (Moscow)
- Institute of Computational Mathematics and Mathematical Geophysics SB RAS (Novosibirsk)
- Institute of Atmospheric Optics SB RAS (Tomsk)
- Institute of Chemical Biology and Fundamental Medicine SB RAS (Novosibirsk)
- Shemyakin-Ovchinnikov Institute of Bioorganic Chemistry RAS (Moscow)

Potential collaborative research areas:

- Anthrax
- Avian Flu
- Tularemia
- Pneumonic Plague
- Aerosol Biology
- Antivirals and Novel Therapeutics

Point-of-Contact



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CENTER FOR BIOSECURITY RESEARCH

BA04MSB010

Next Generation Chem Bio Battle Management System

Jim Reilly
AFRL/IFSA
james.reilly@rl.af.mil

26 October 2005

Outline

- Overview of CBRN Battle Management
  - Battle Management Decision Loop
  - CBRN Data Model
  - NGCBBM Decision Loop
- Examples of CBRN Information Management
  - Sensor / Actuator interaction
  - Analysis and assessment
  - Status
  - Response plans
- Examples of Operational Environment System Configuration
  - Data Acquisition
  - Operation Across Guards
  - Multi-level Data Processing
- Conclusions

CBRN Battle Management

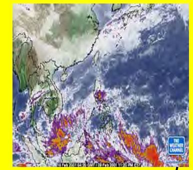
- Create an sufficiently accurate and understandable representation of the real world to provide actionable information which the warfighter can use to effectively influence the real world in real time.

- Build a tool the warfighter recognizes
  – Improve acceptance
  – Make use of centuries of evolution
  – Play CONOPS/technology leapfrog

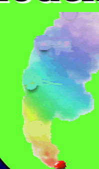
Battle Space

Force Protection

Met Data



Hazard Models



NBC Recon

Battlefield Situational Awareness

Attack Events

Sensor Data

Operational Status

LG, SF, TRANS,
OPS, FD, EOD, ETC…

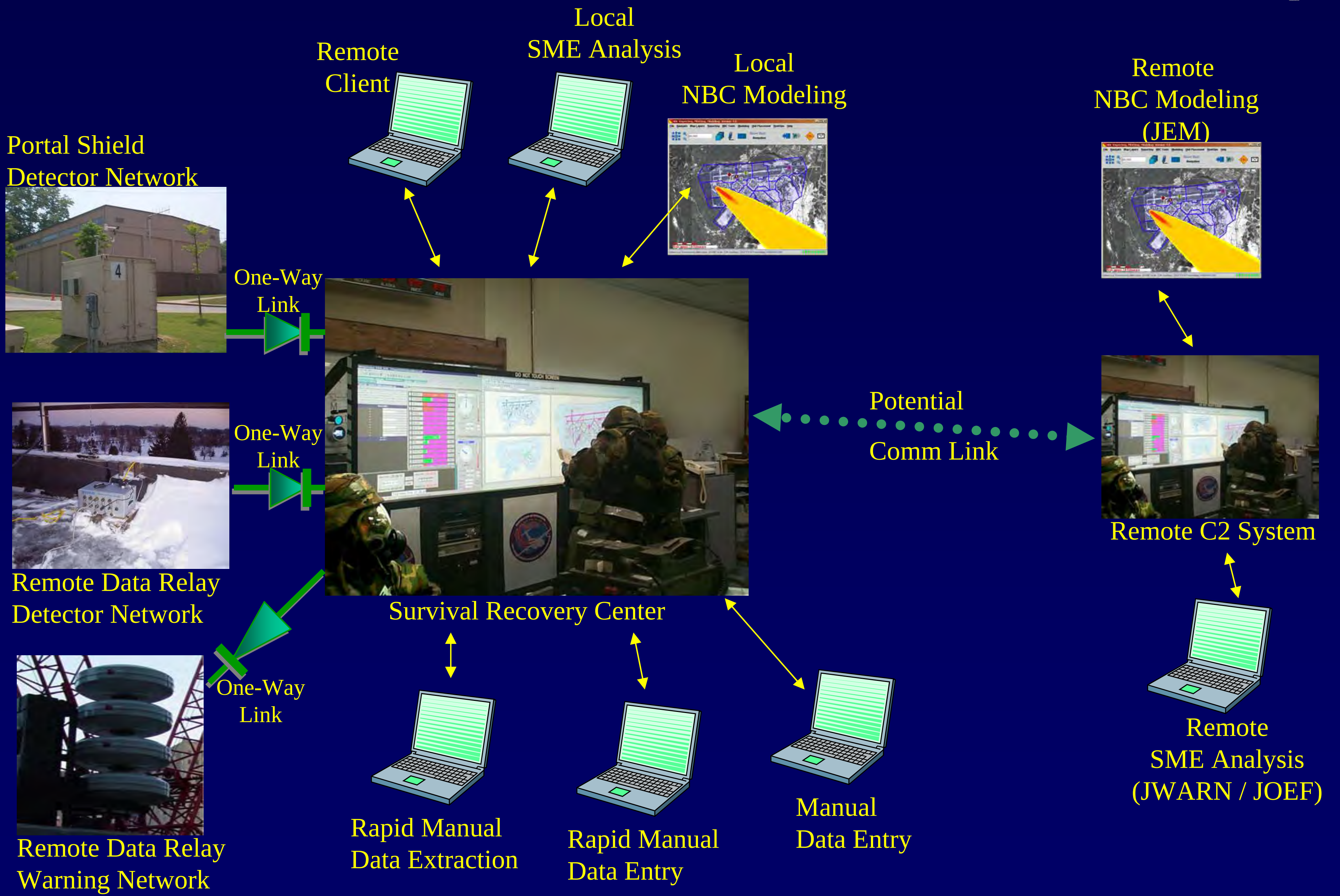
CBRN
Battle Management Questions

- What is it?
- Where is it?
- What is the impact on missions?
- How long will impact last?
- What will change the extent, degree or length of impact?
- What confirms/contradicts a change in impact?

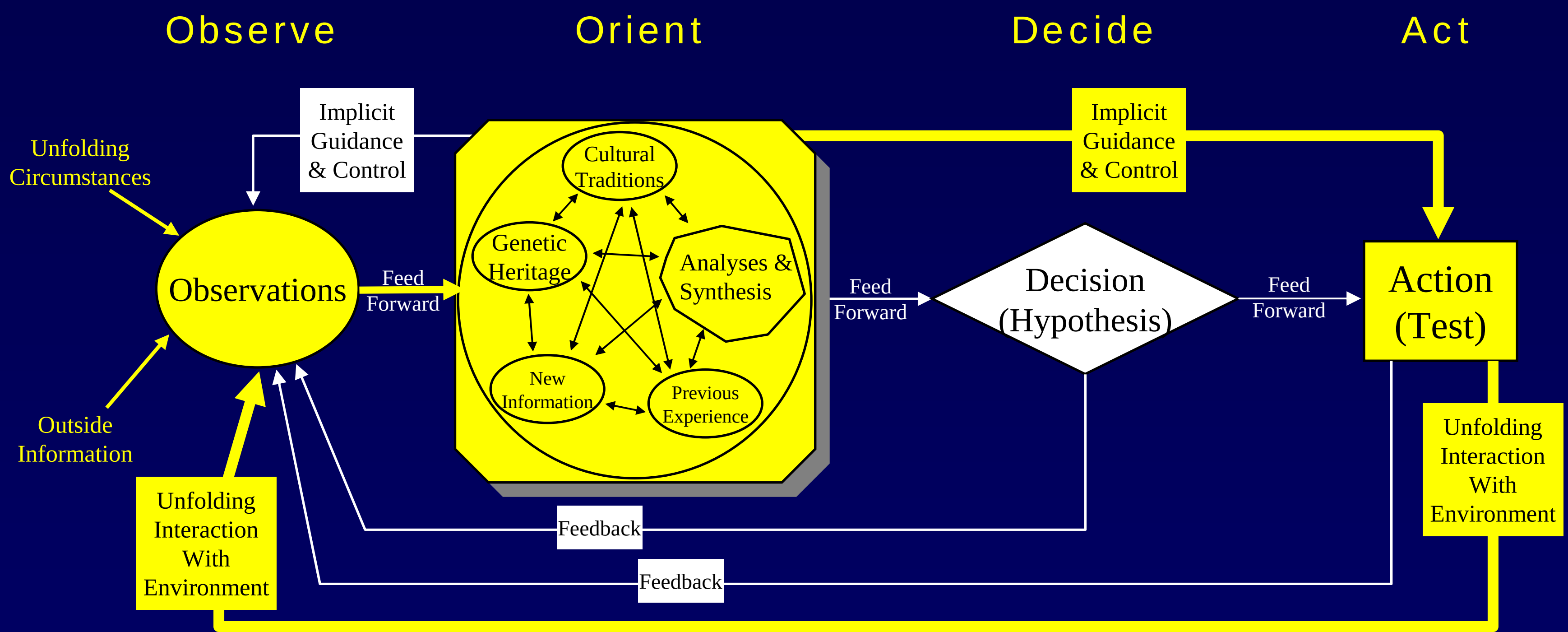
Battle Management Spectrum

Fixed Site (RestOps)	Expeditionary Site (CASPOD)	Mobile Site	Incident Response (IMCR)
Fixed Participants	Know Participants	Know Participants	Unknown Participants
Fixed Infrastructure	Portable Infrastructure	Mobile Infrastructure	Any Infrastructure
Well Defined Mission	Defined Mission	Defined Mission	Save Lives
Train Together	Coordinated CONOPS	Coordinated CONOPS	Limited or No CONOPS
Years to prepare	Weeks to Prepare	Hours to Prepare	Hours to Prepare
Single Platform	Multiple Platforms	Multiple Platforms	Any Platform

Chem/Bio Battle Management



Boyd's OODA Loops



From "The Essence of Winning and Losing," Col John R. Boyd, January 1996.
Defense and the National Interest, http://www.d-n-i.net, 2001

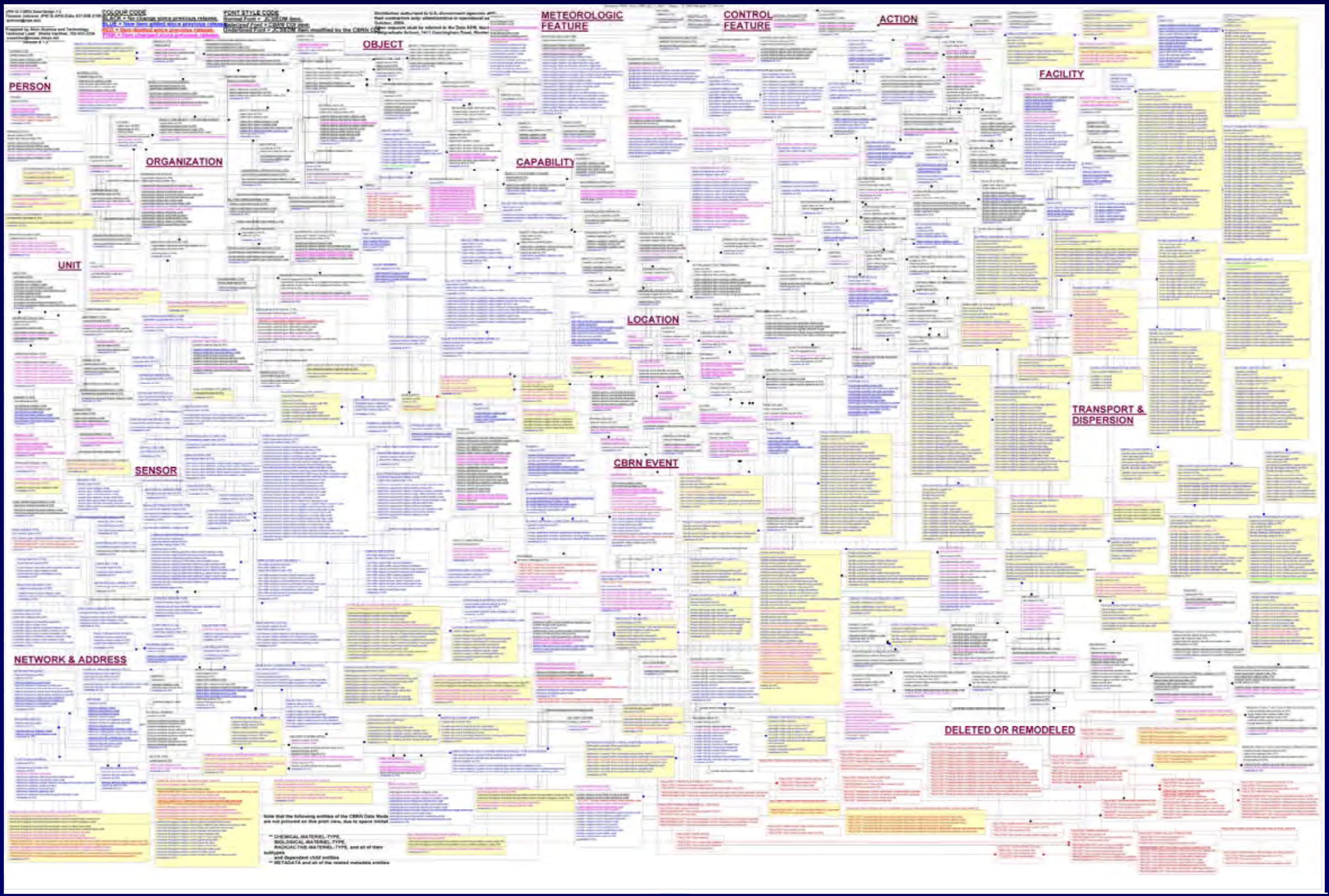
OODA Use Day to Day

- Humans process OODA loops continuously
  - Poor decisions are failures in the OODA loop
  - Katrina response was a failure in the OODA loop of individuals and organizations
  - A good employee is one that can process the OODA loop at their level
    - Vehicle maintenance checklists
      - Refuel the vehicle
    - Provide the status report
    - Provide course of action to address inadequate status for mission

- Sensors/Detectors process OODA loops according to a static or dynamic plan
  - Detector Processing - Sampling time, detection limit, alarm type
  - RDR Communication Node Processing -
  - RDR Command Post Processing -
  - IIMS Processing –

- In practice, OODA Loops need to address:
  - Bandwidth management
  - Processor management
  - Storage management

CBRN Data Model



What types of information management does this enable?

What kinds of field configurations does this enable?

NGCBBM System Approach

- Tie OODA Loop to common military functions
  - Data analysis
  - Asset status for a mission
  - Response checklists

- Generalize military functions
  - Generalize service specific functions
    - “The Army doesn’t do split MOPP”
  - Generalize event/status/entity functions
    - Runway / pier / shipping channel / road

- Use CBRN Data model as basis for the battle management system

NGCBBM Data Base and Code Structure

Decision Making
as a Function of Mission

Analysis – Resource Status – Response Plan

↓ ↑

Mechanisms for Interaction with Resources

Sensors/Detectors and Actuators

↓ ↑

Resources of Interest for a Mission

(Entities)

NGCBBM Data Base and Code Structure

Decision Making
as a Function of Mission

Analysis – Resource Status – Response Plan

Structured Messages
USMTF
CAP

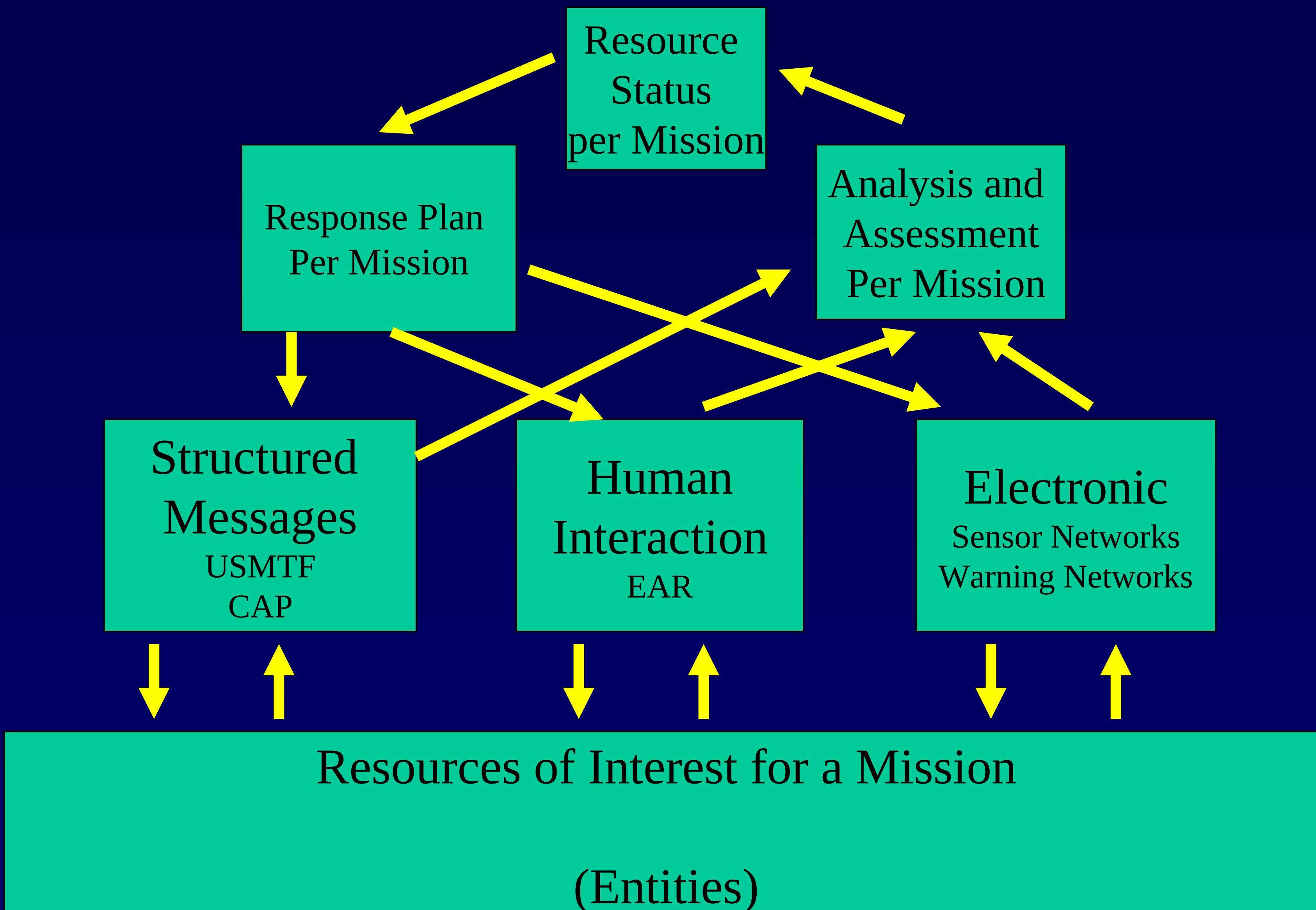
Human Interaction
EAR

Electronic
Sensor Networks
Warning Networks

Resources of Interest for a Mission

(Entities)

NGCBBM Data Base and Code Structure



NGCBBM Data Base and Code Structure

Entity_Status
- Mission Capability
- ThreatCON
- FPCON

Status of our resources for a specific mission

Action Event / Mission Plan / Support Plan
- Sweep — Assets w/ Consumables
- Warn
- Checklist
- Battle Plan
- Dynamic SME Response
- Refuel
- Eat/rest
- Organizational Structure

Dynamic or planned events (act or sense) in response to status for a specific mission

Event_Entity Analysis and Assessment
- Data Point
- SME Analysis
  - Tag
- Automated Analysis
  - Model

Analyze events to determine entity status for a specific mission

Event_Remote
- USMTF
- OTH Gold
- CAP
- EDXL

Reference data
Two-way interaction

Event_Human
- Sensor
- Detector
- Actuator

Action Request
Attack or Activity Report
Local event through
Human interface

Event_Electronic
- Sensor
- Detector
- Actuator

Local event through
Electro-mechanical interface

Entity / Entity_ Properties Features / Entity_ Allegiance
- Region
- Transportation Infrastructure
- Utility Infrastructure
- Platform
- Facility
- Equipment
- Consumable
- Individual

Country / Base

Organization

Entity is any resource that can be used to change the real world

Resources combined for a mission form a higher level entity

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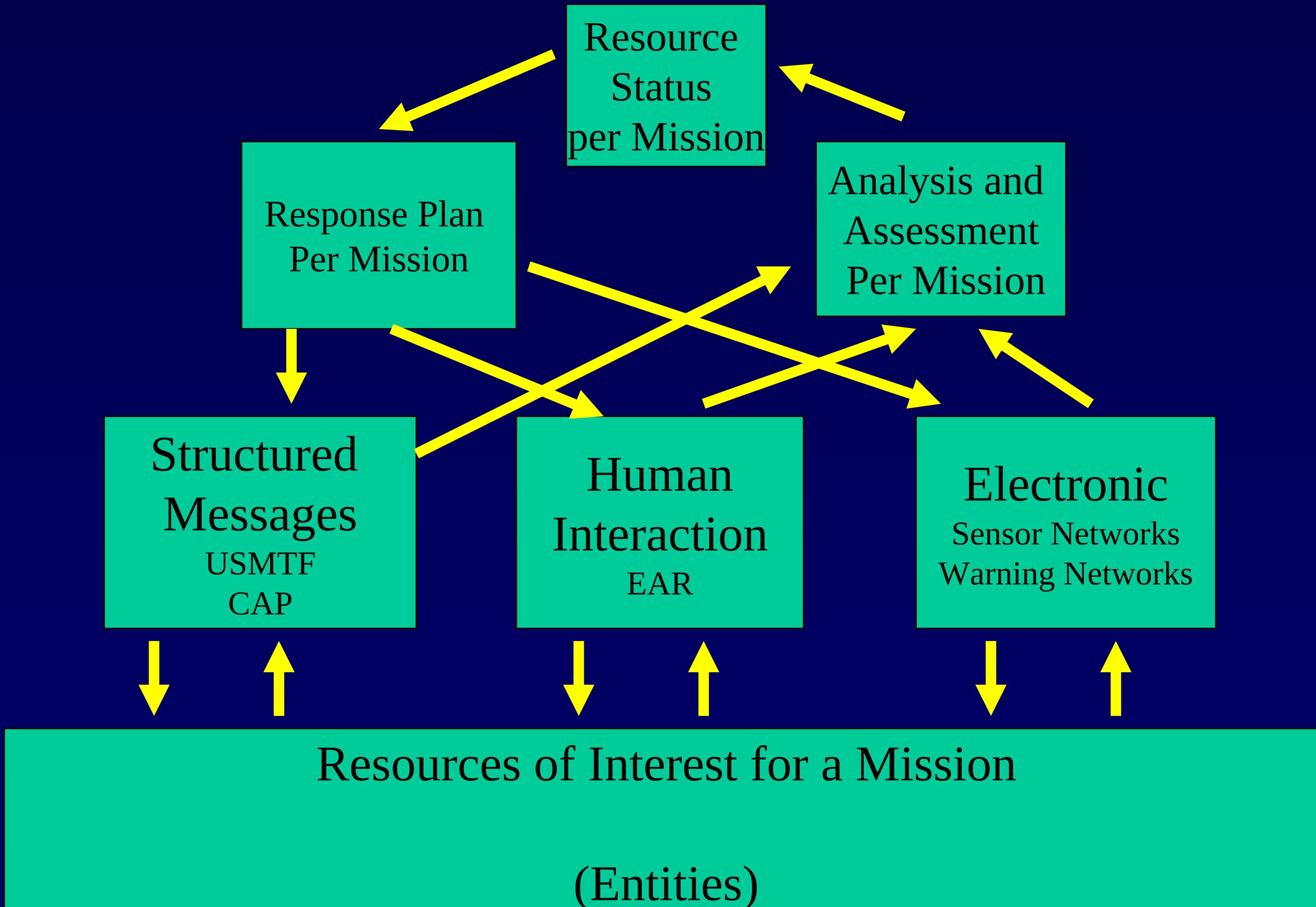
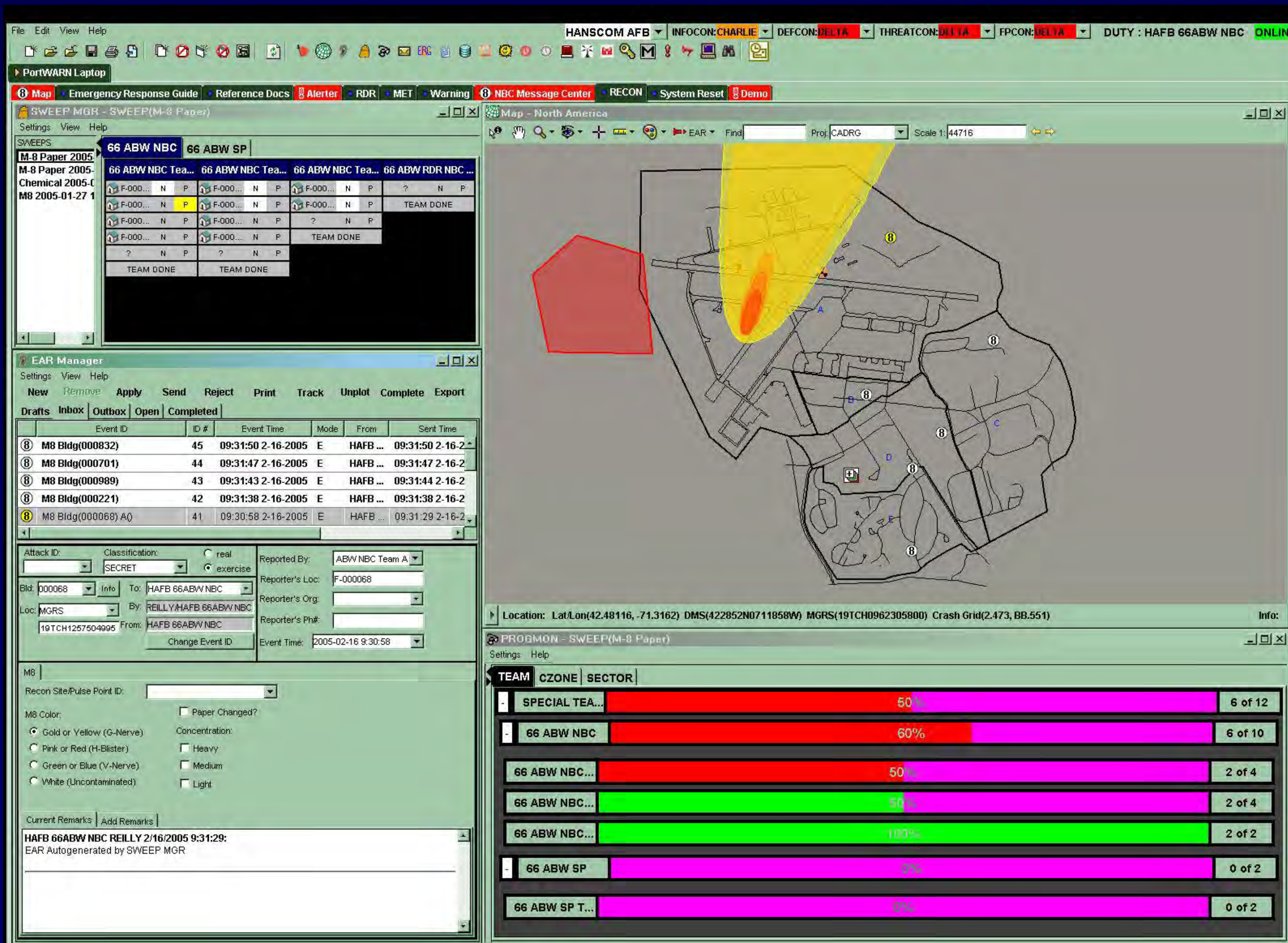
NGCBBM Data Base and Code Structure



Data Acquisition

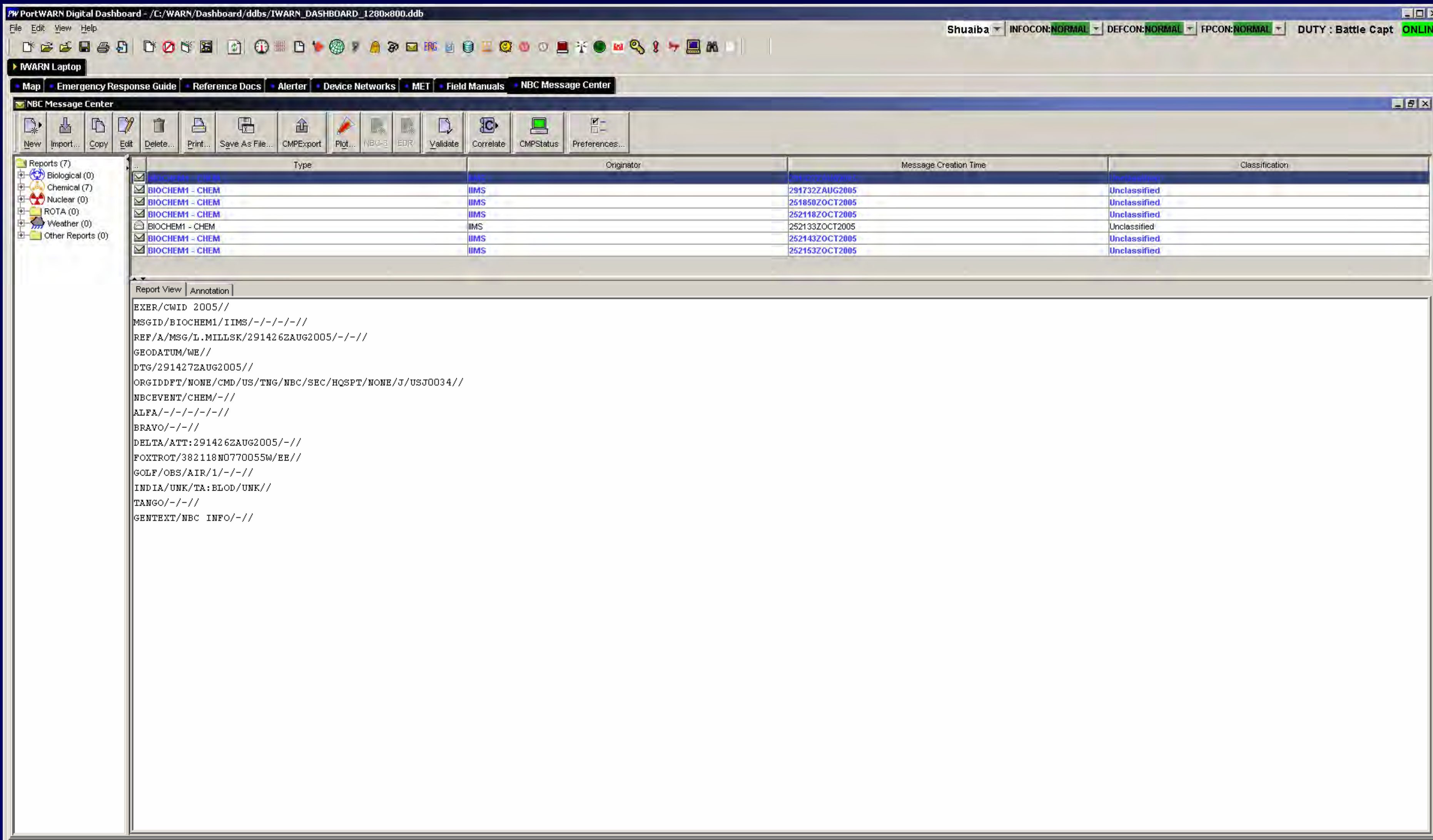
- Reference
  - Map Data
    - NGA
    - GeoBase
    - Commercial
  - Hot Links
  - Reference Databases
  - Reference Documents
  - Emergency Response Guidebook
- Manual
  - EAR
  - StatRep
  - Region or ThreatCON Status
  - Drawing Map Layers
- Rapid Manual
  - Sweeps
- Information Extraction
  - Patrol Debriefing Tool
  - Turbo Tax type interface
- Streaming Electronic
  - Portal Shield
  - Remote Data Relay
  - JCID
  - Force Protection Sensors
  - Met
  - GCCS Track Data
  - JWARN and JEM

Sweep Interface

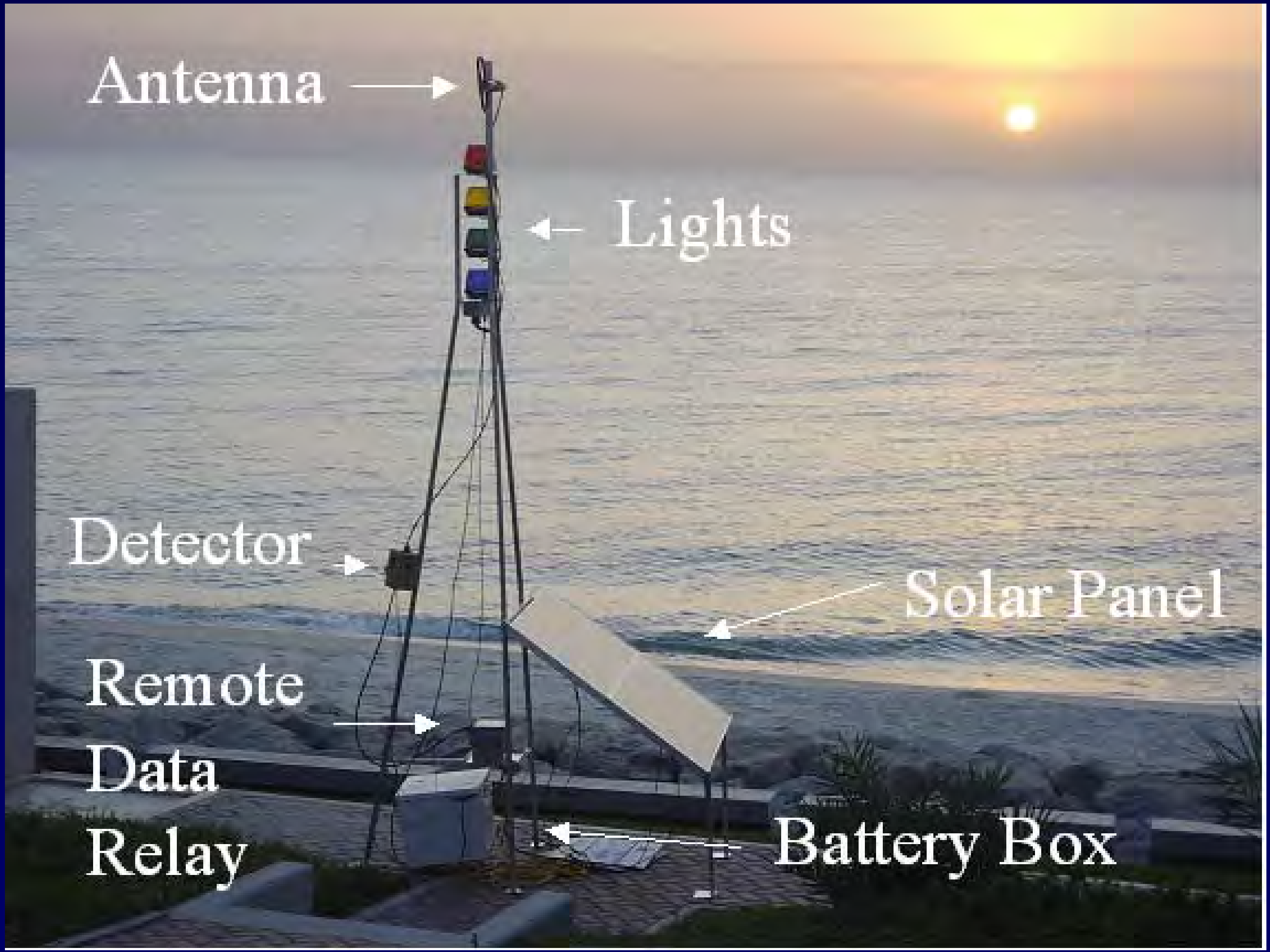


Information Extraction

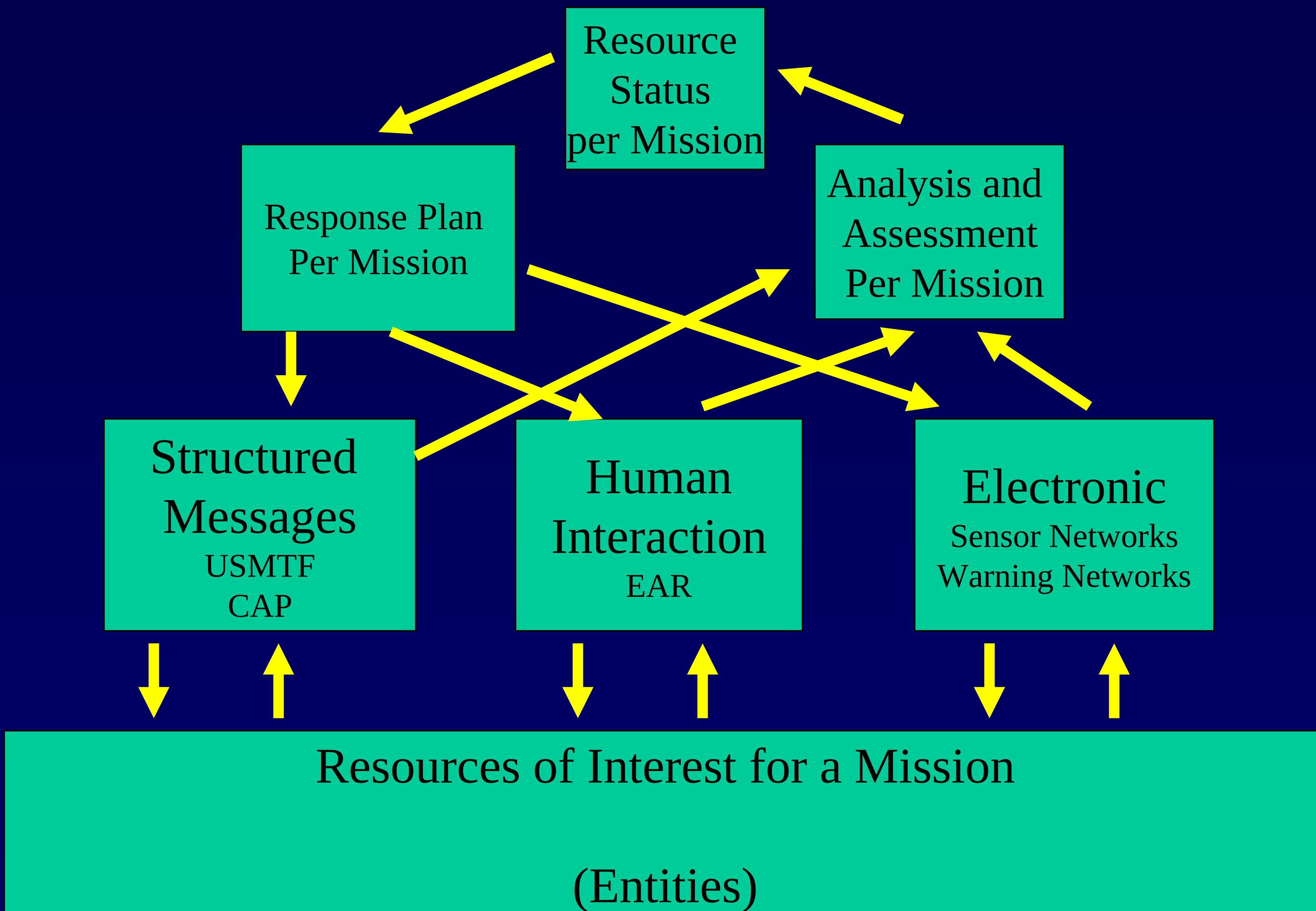
CBRN Messaging



CBRN Warning



NGCBBM Data Base and Code Structure



Information Cataloging and Aging

- I saw the cloud two hours ago
- I detected residue 30 min ago
- I saw the effects one hour ago
- I detected the cloud 115 min ago
- I modeled the cloud 90 min ago
- The CONOPS are ….
- Intel says the cloud would most likely have been ….
- Local newspaper reported in Oct_03 …..
- DECON had this impact ….

Information Tagging and Filtering

- Manual Tagging and Filtering
  - Plot on COP and Major Event List
  - Plot on Local COP and Major Event List
  - Region of Interest
  - Organization of Interest
  - Information Type of Interest
  - Information Topic of Interest
  - Classification

- Automated Tagging and Filtering

Sensor Data

- When is sensor data significant enough to detect, record and report?
- Rules are built into the detector and the detector network
  - Do you know what the rules are and how they impact your high level data interpretation?
- How do you combine data collected under different rules?
  - Sampling bias

Models

- Impact Regions (NBC 4-5-6) - Impact level on Region and Assets
  - Actual hazard on the ground
  - Hand drawn region

- Impact Region Models (predictive models) - Impact level on Region and Assets
- Transport and Diffusion
  - JEM
  - ATP-45
  - HPAC
  - ALOHA
  - VLSTrack
  - Met (e.g. precipitation)
  - Flooding
  - smoke
  - Other than attack
    - CAMEO
    - ALOHA
    - ERG
    - D2PC
  - Flooding data
  - Snow/Ice Storms
  - Stability Category Wizard
  - ITRANS
  - Urban Dispersion Model
  - MINT – Missle Intercept

- Operational Impact Models – Impact on Operations – Effect Models
  - Manual Status
  - JEM
  - JOEF
  - Heat Stress
  - Cold Stress
  - Smoke
  - STAFFS
  - Casualty Rates
  - NBC CREST

- Effects Calculators
  - NBC Planner

- Recovery Models
  - Resources required for Protection and Recovery

- Protection Effectiveness Models
  - None
  - Vulnerability Assessment Table (VAT)

- Passive and Active DECON Models
    - Is DECON needed or not?
    - What type of DECON is needed – Hasty vs deliberate, assets needed
    - Snowplow
    - Manual Measurement

- Course of Action Analysis
  - JOEF
  - Effects Based Operations
  - DECON Site Design
  - NCBR – show contamination of assets – ITT force decon.
  - Acquisition Analysis

- Probability Analysis

Can You Run Your Model?

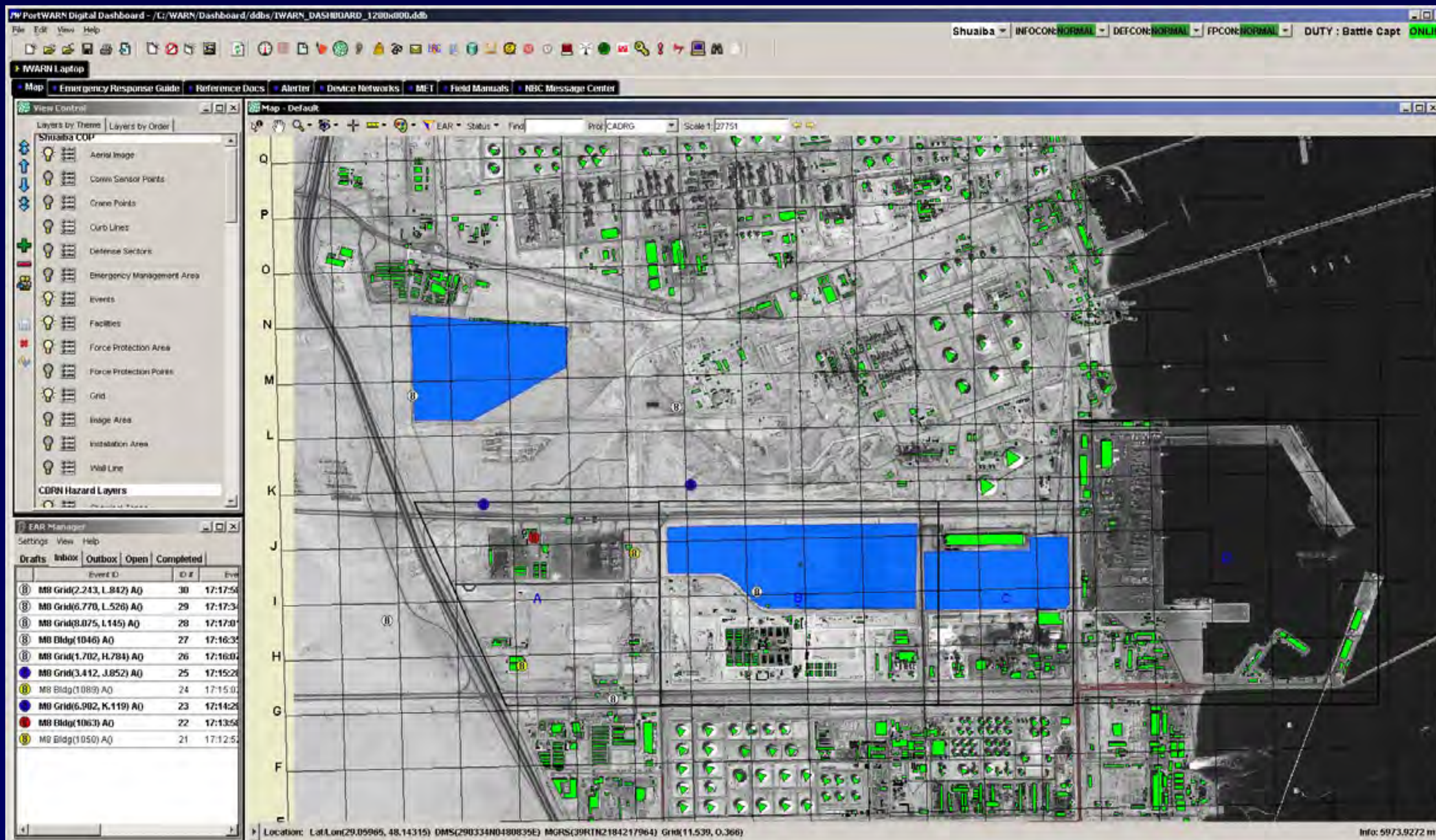
- CBRN Modeling Message is Needed
  - Ground contamination vs vapor
  - Sensor vs field observation
  - Vapor hazard vs liquid hazard
  - Sensors you don’t own?
  - Models you don’t own?

- Common Modeling Parameters which can be filtered based on Classification

Data Aging

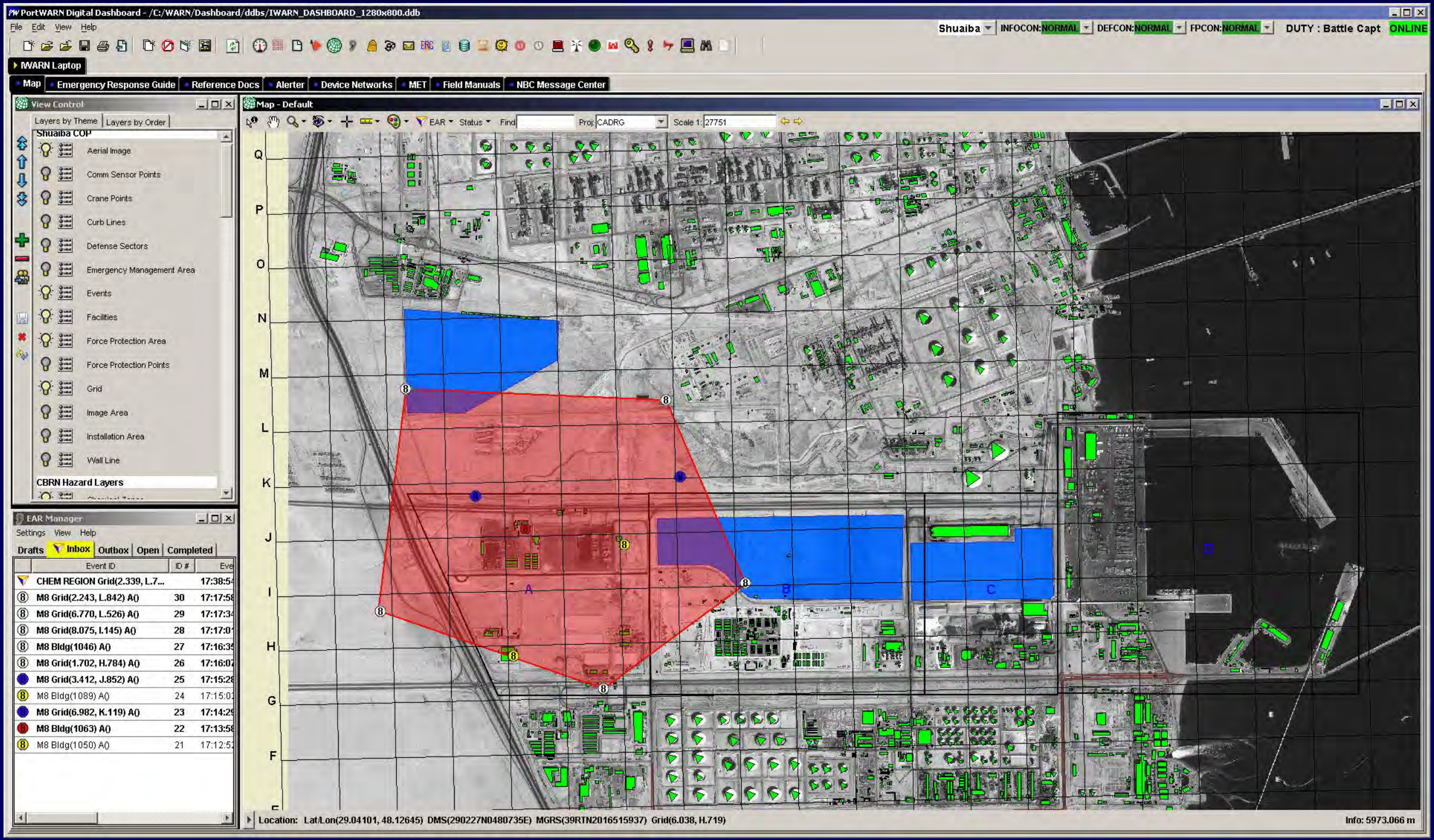
- How do you convey the currency of detection?
- MCAD Passive IR Absorption detection lines can overwhelm the user
- Aging of detection lines based on:
  - Time
  - Wind
  - Other environmental parameters?
  - CHEMRAT
- Automated Chem Region Polygon generation and aging of the chem regions
  - Time
  - Wind
  - Other environmental parameters?
  - CHEMRAT
  - Decon
    - Falcon or GL1800
    - Water
    - Bulldozer

M8 Detection



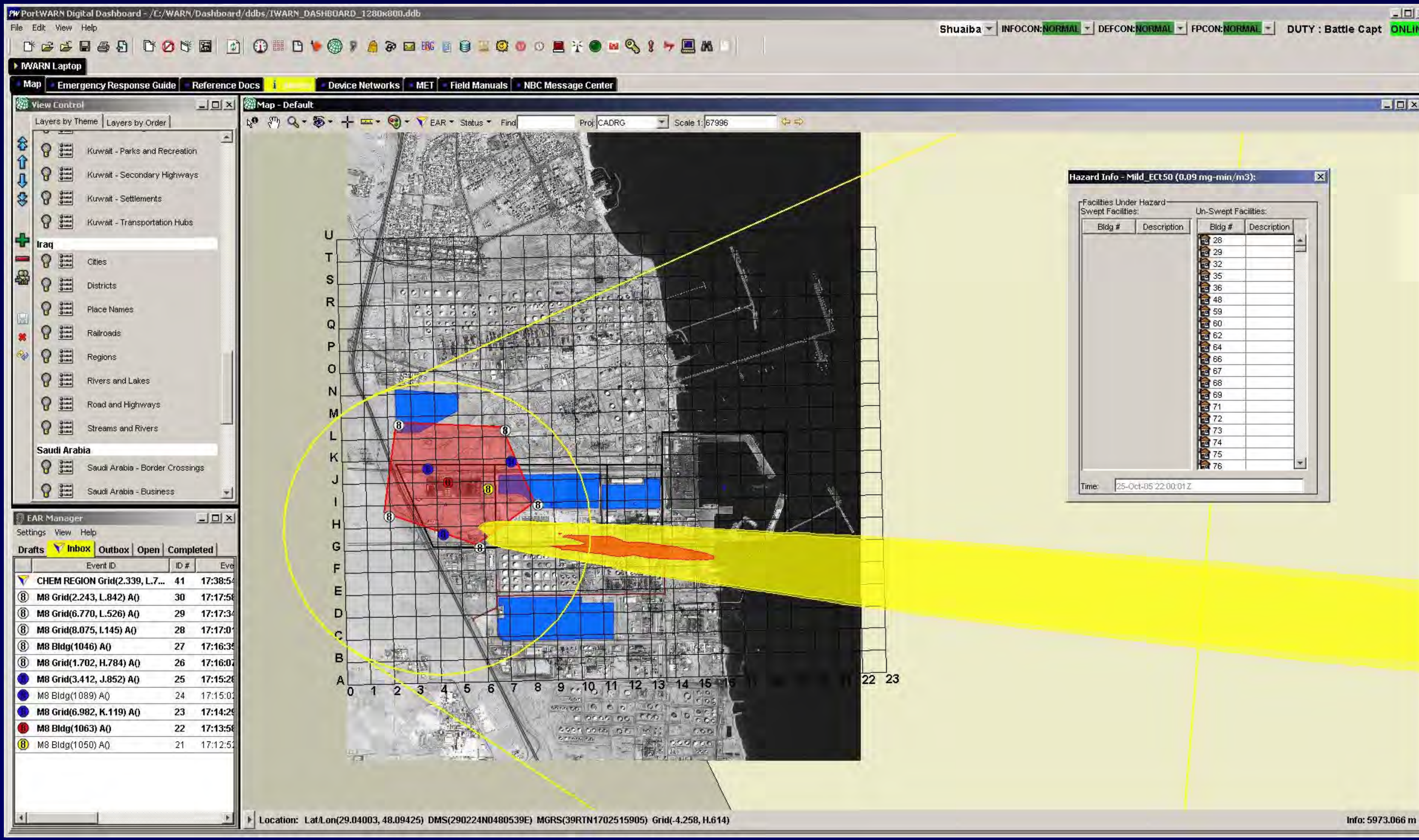
- Detections analyzed and believed to be real
  - SME evaluated the data points

Chem Region Drawn by SME



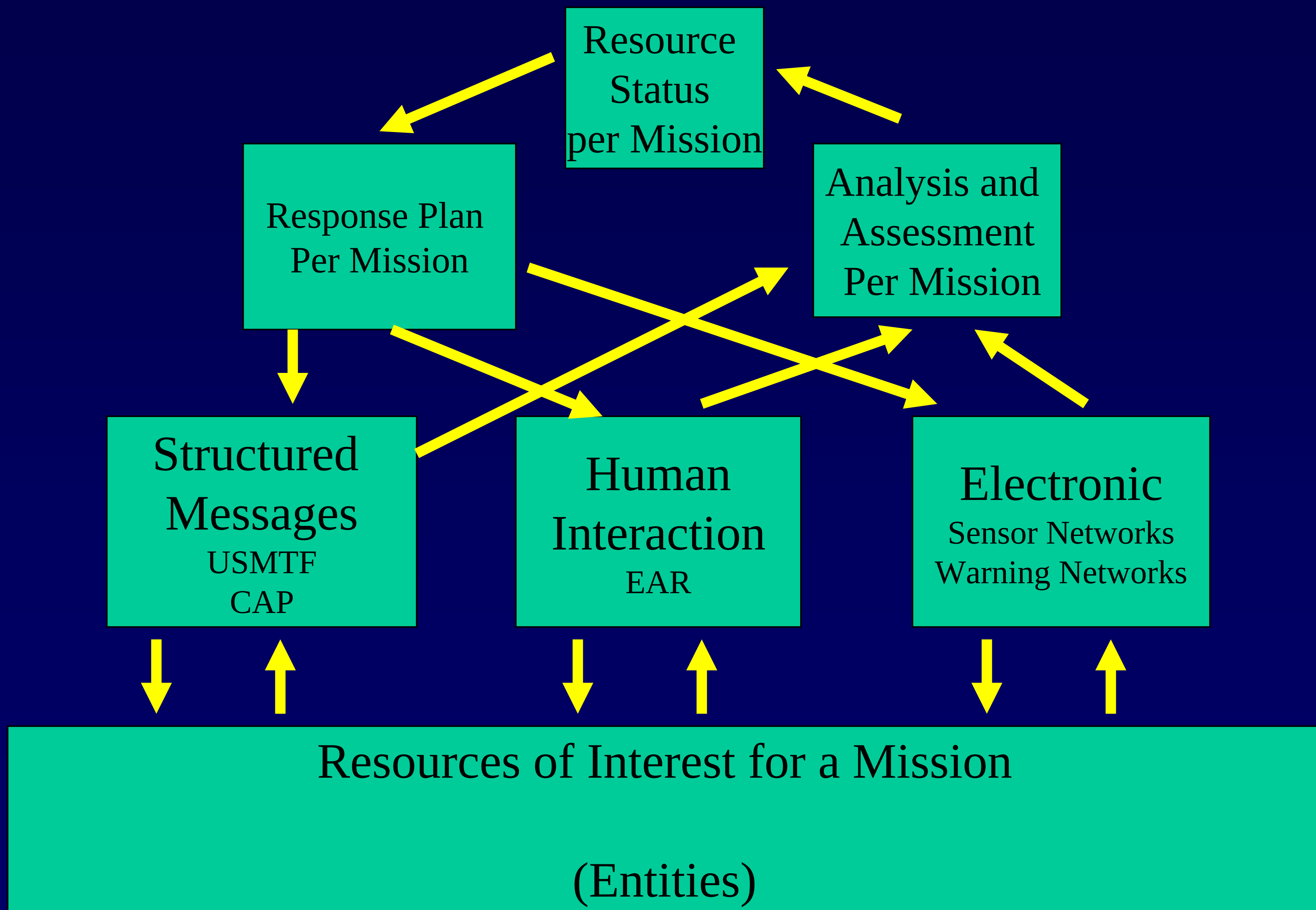
- SME determines region contaminated at level of detections
  - Manually tag data points to region and resources in it according to SME

Contaminated Region from Model

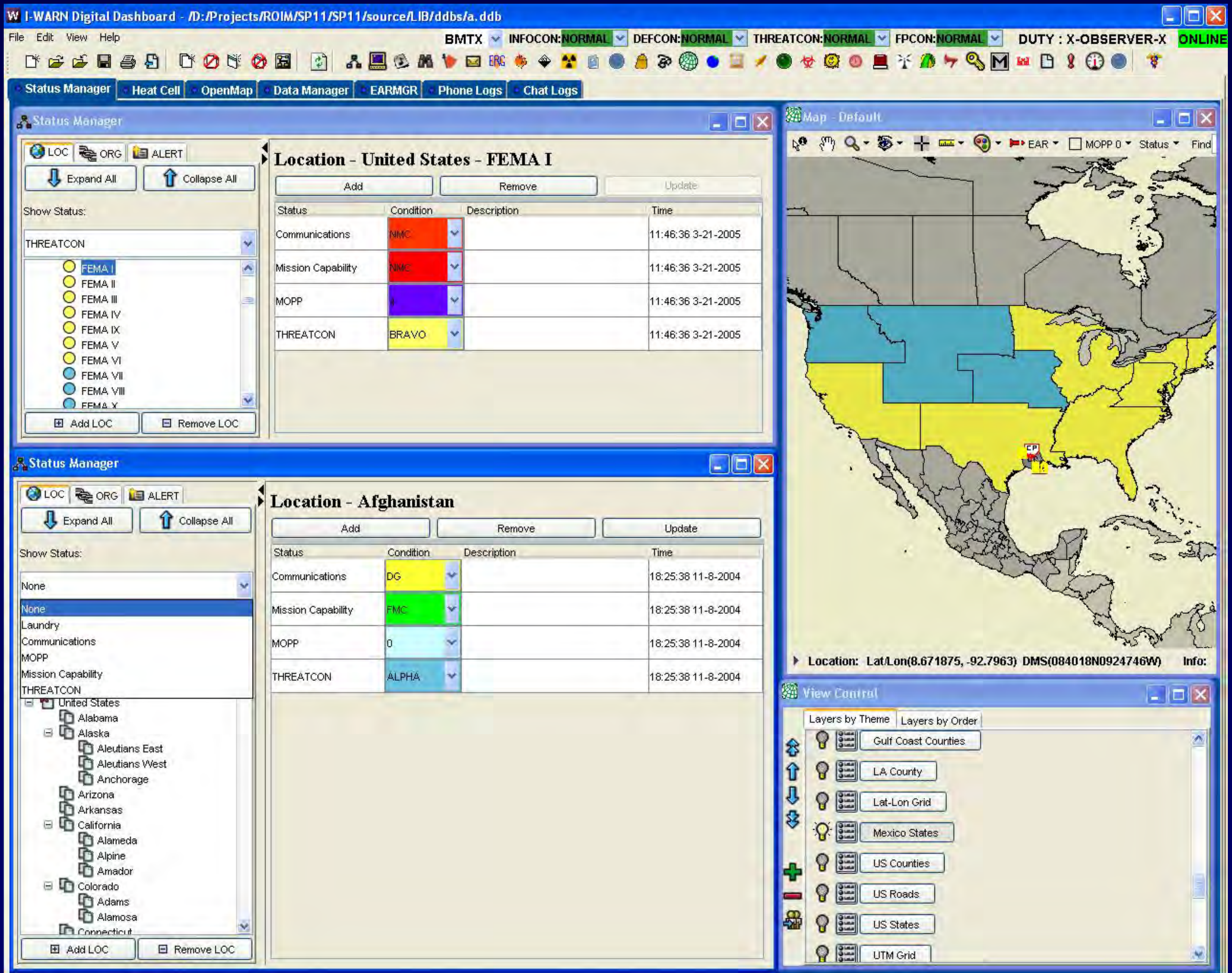


- Model predicts contamination levels based on detections and formalized SME
  - Automated tagging of data points to region and resources in it

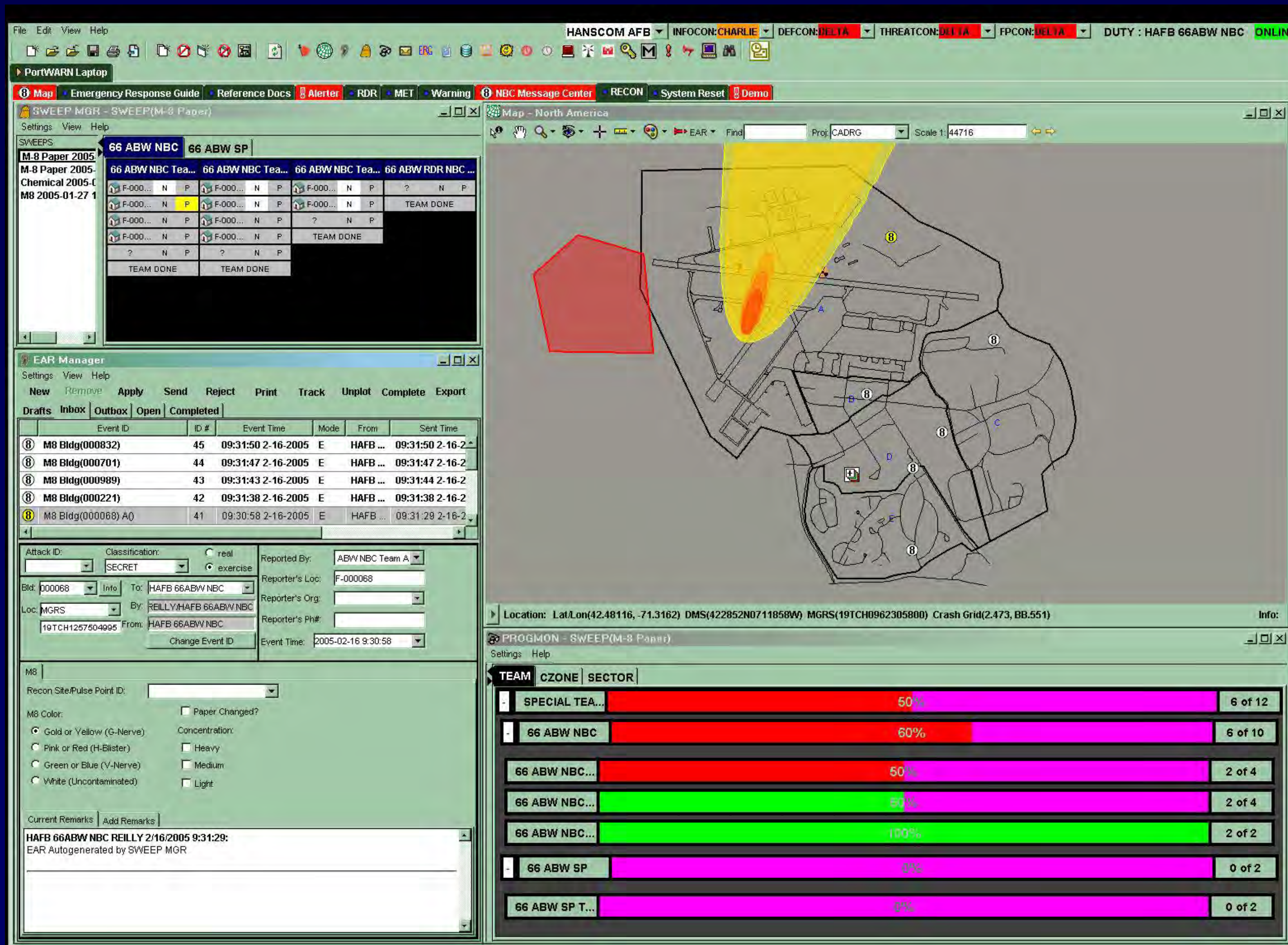
NGCBBM Data Base and Code Structure



Status Summary and CON Toolbar



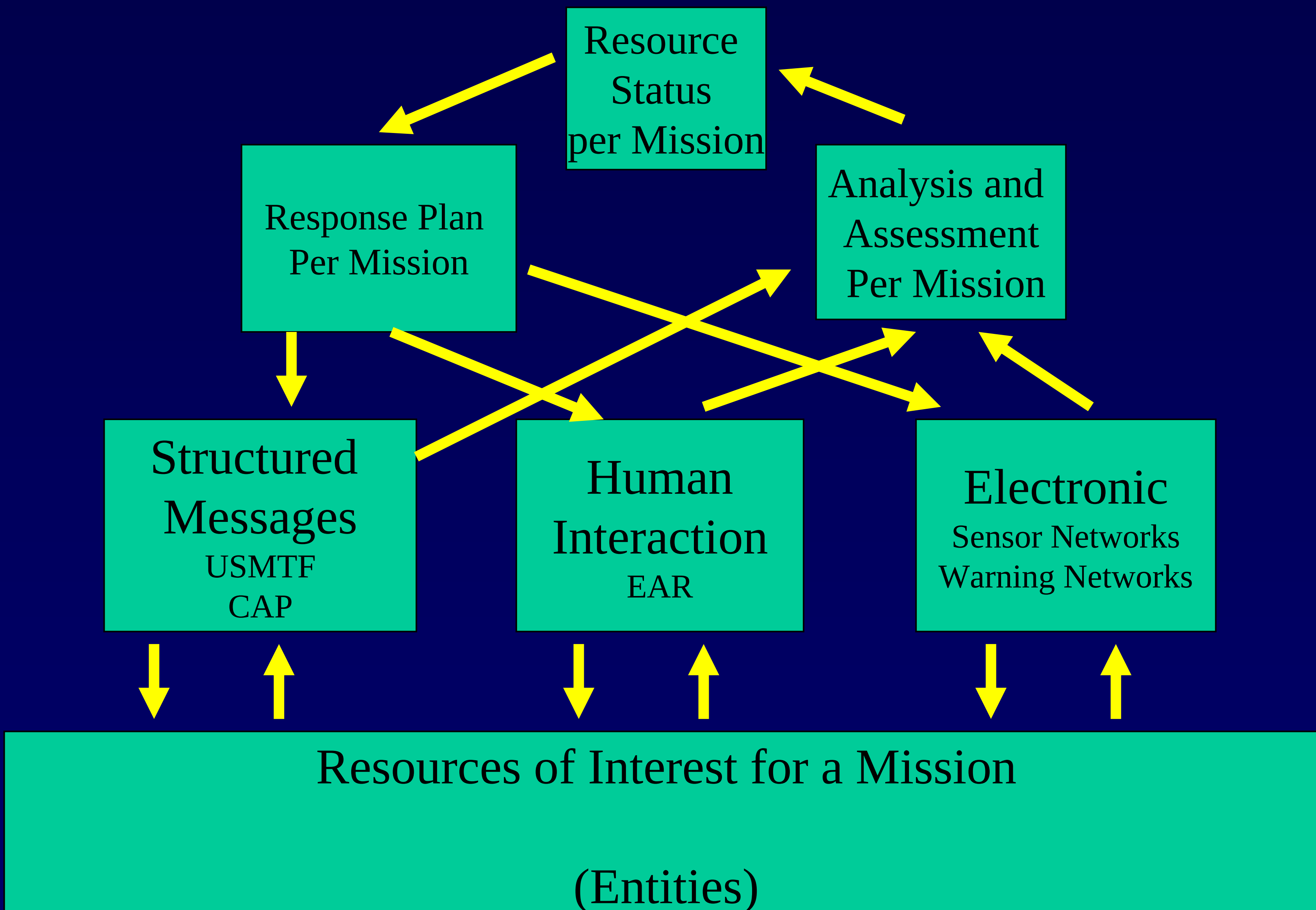
Sweep Manager and Progress Monitor



Status of Which Resource?

- “Detector Faulted” is the status of the detector
  - May imply unknown status for region
- “Detector Clear” is the status of the point
  - May imply known status for region
- “Detector Alarm” is the status of the point
  - May imply known status for region
- “Comms Down” is the status of the network
  - May imply unknown status for region
- “MOPP None” is the status of the region
  - Implies MOPP status for all resources in the region

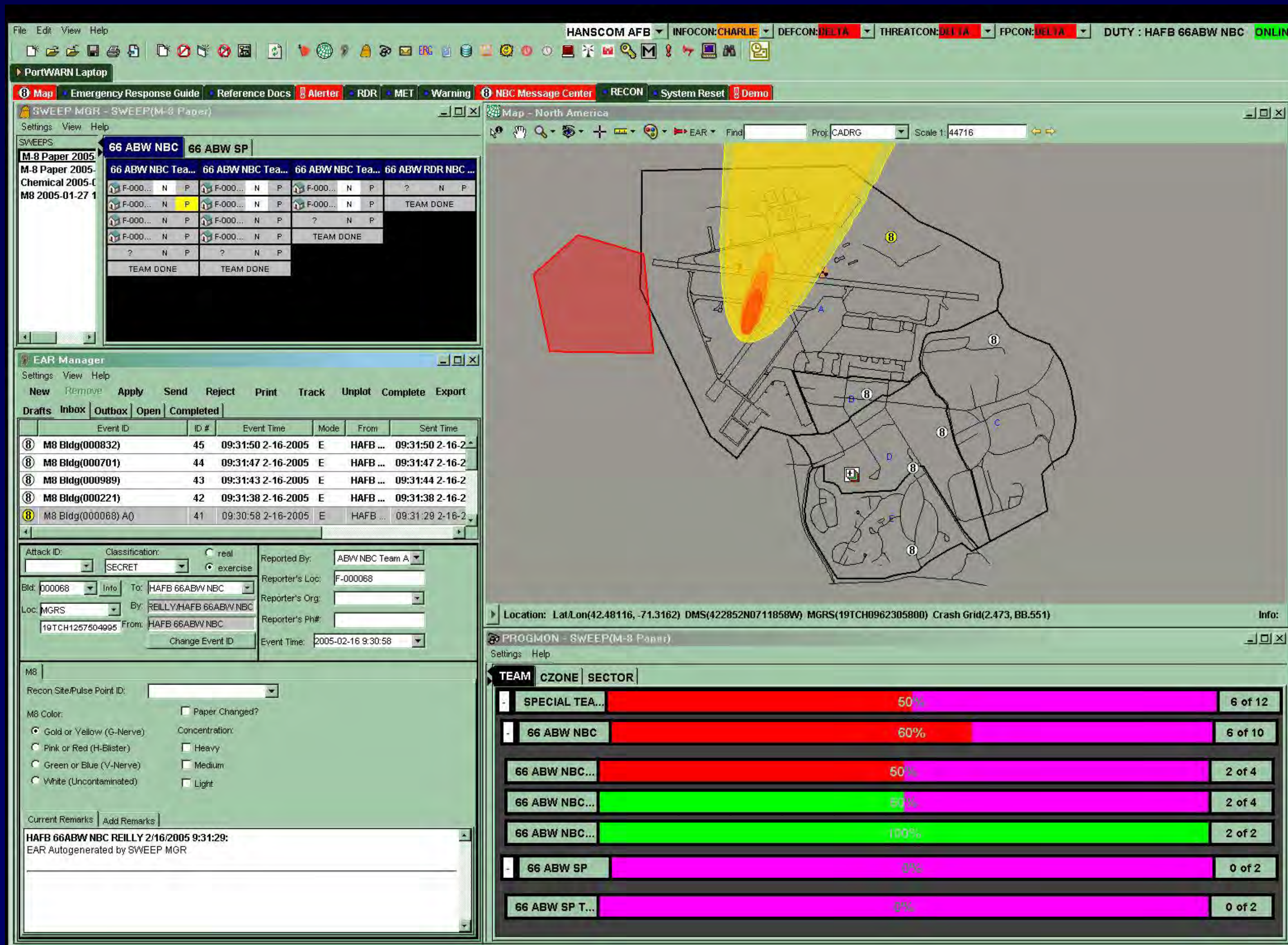
NGCBBM Data Base and Code Structure



Response Plans

- No Timeline
  - Simple checklist
- Static PowerPoint with Timeline
- Electronic Timeline
- Electronic Timeline with Resource Conflict Notification
- Electronic Timeline with Suggested Courses of Action

Sweep Manager and Progress Monitor



Guidance

- Passive Guidance
  - Display of Contaminated Regions
  - Reference Documents (CONOPS, ATSO Guide)
  - Static Response Plan (PowerPoint)
  - Databases (Emergency Response Guide)

- Active Guidance
  - What do I need to be reminded of?
  - What information do I need to run a different model?
  - Sensitivity Analysis – How critical are the different parameters in a model?
  - Sensor Placement
  - What information would change my understanding of the situation around me?
  - Asset conflicts in response plans
  - Suggested Course of Action

Active Guidance

- Given:
  - Assets in a Region
  - Asset work load
  - MOPP Condition
  - Weather
- Provide Guidance on:
  - Time assets in MOPP
  - $H2O$ Consumption
  - Work Rest Cycle
  - Total work time per shift
- Provide Inputs for Operational Throughput Models

Heat Index Guidance

I-WARN Digital Dashboard - /D:/Projects/ROIM/SP11/SP11/source/LIB/ddbs/a.ddb

File Edit View Help

BMTX INFOCON:NORMAL DEFCON:NORMAL THREATCON:NORMAL FPCON:NORMAL DUTY : X-OBSERVER-X ONLINE

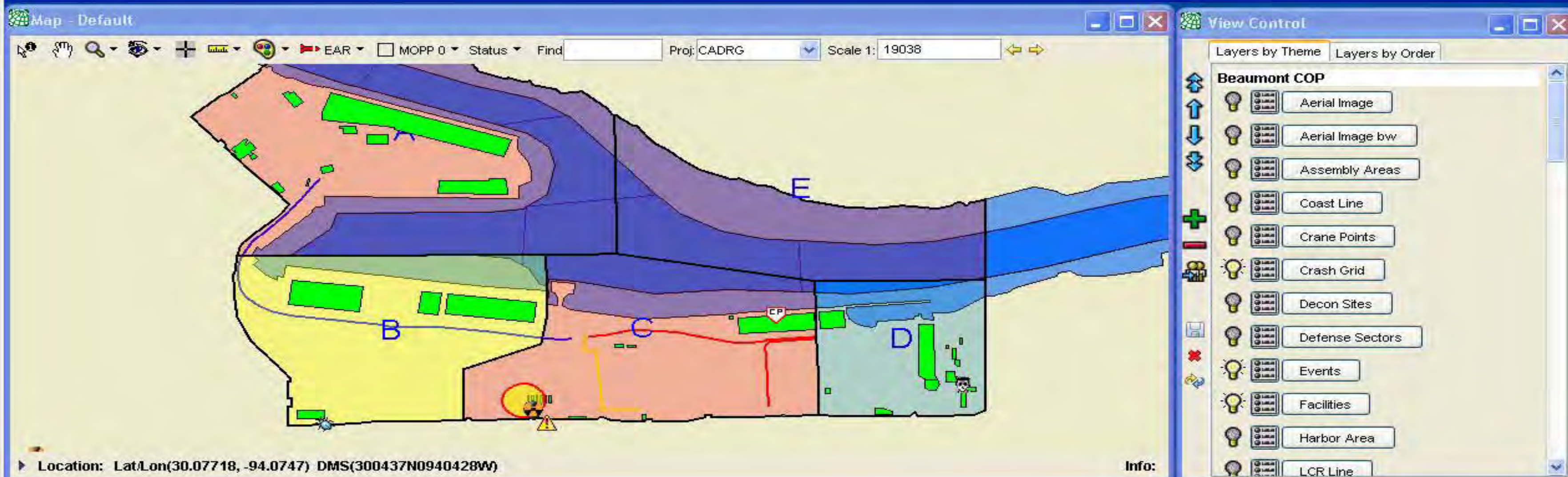
Status Manager | Heat Cell | OpenMap | Data Manager | EARMGR | Phone Logs | Chat Logs

Work Rest Guidance - Work Cycle Guidance

Meteorology Data Source: Manual ⦿ Real ○ Exercise

Work Cycle Guidance | Work Shift Maximums Reference | Work Intensity Reference | Heat Index Reference

Cycle Started	Zone	MOPP	Time In MOPP	Time Before Next Cycle	Heat Index (F)	Ambient (F)	MOPP over Underwear								MOPP over Battle Dress Uniform							
							VL		L		M		H		VL		L		M		H	
							W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr
2004-10-20 11:25:53	A	MOPP 4	5 days 21 hours 21 minutes	58 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA
2004-10-10 13:20:46	B	MOPP 2	12 days 20 hours 18 minutes	53 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA
2004-10-04 10:31:20	C	MOPP 4	18 days 20 hours 34 minutes	4 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA
2004-10-17 13:19:36	D	MOPP A	12 days 20 hours 18 minutes	52 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA
2004-10-03 13:03:24	E	MOPP 4	5 days 21 hours 20 minutes	36 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA



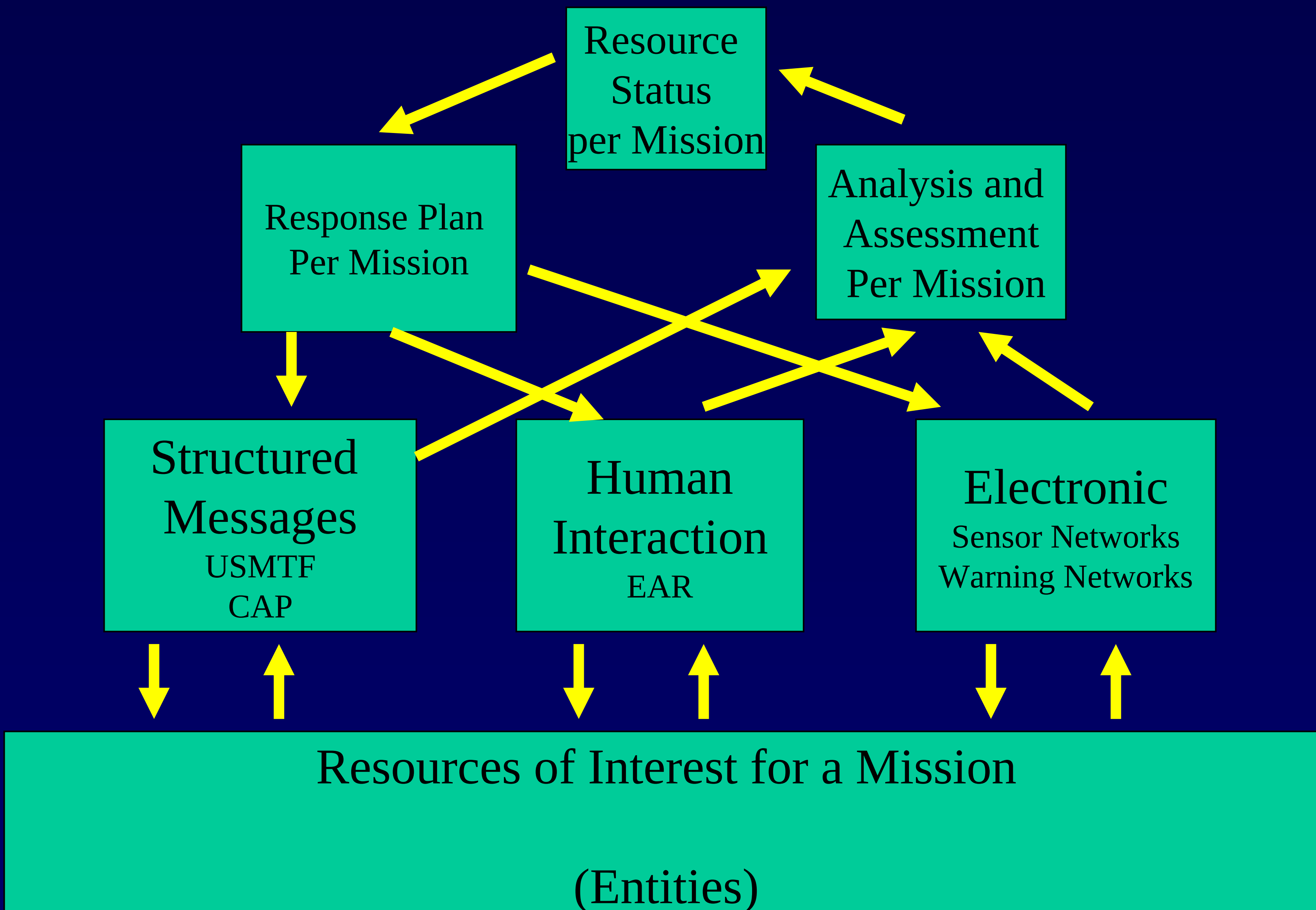
Example 1

- Detect or observe chemical incident
- Analyze data by SME or model to determine impact on entities
- Set status of entities for specific missions
  - Flying mission
  - Water table protection
- Determine response by SME or according to preset plan
- Act as required by response
- Monitor resources and re-calculate status

Example 2

- VIP visit reported
- SME confirms it will happen and determines impact
- Change FPCON status
- FPCON change triggers new response plan
  - Change detector sampling rate and deployed forces
- Analyze data for indication of incident
- ….
- VIP visit reported over

NGCBBM Data Base and Code Structure



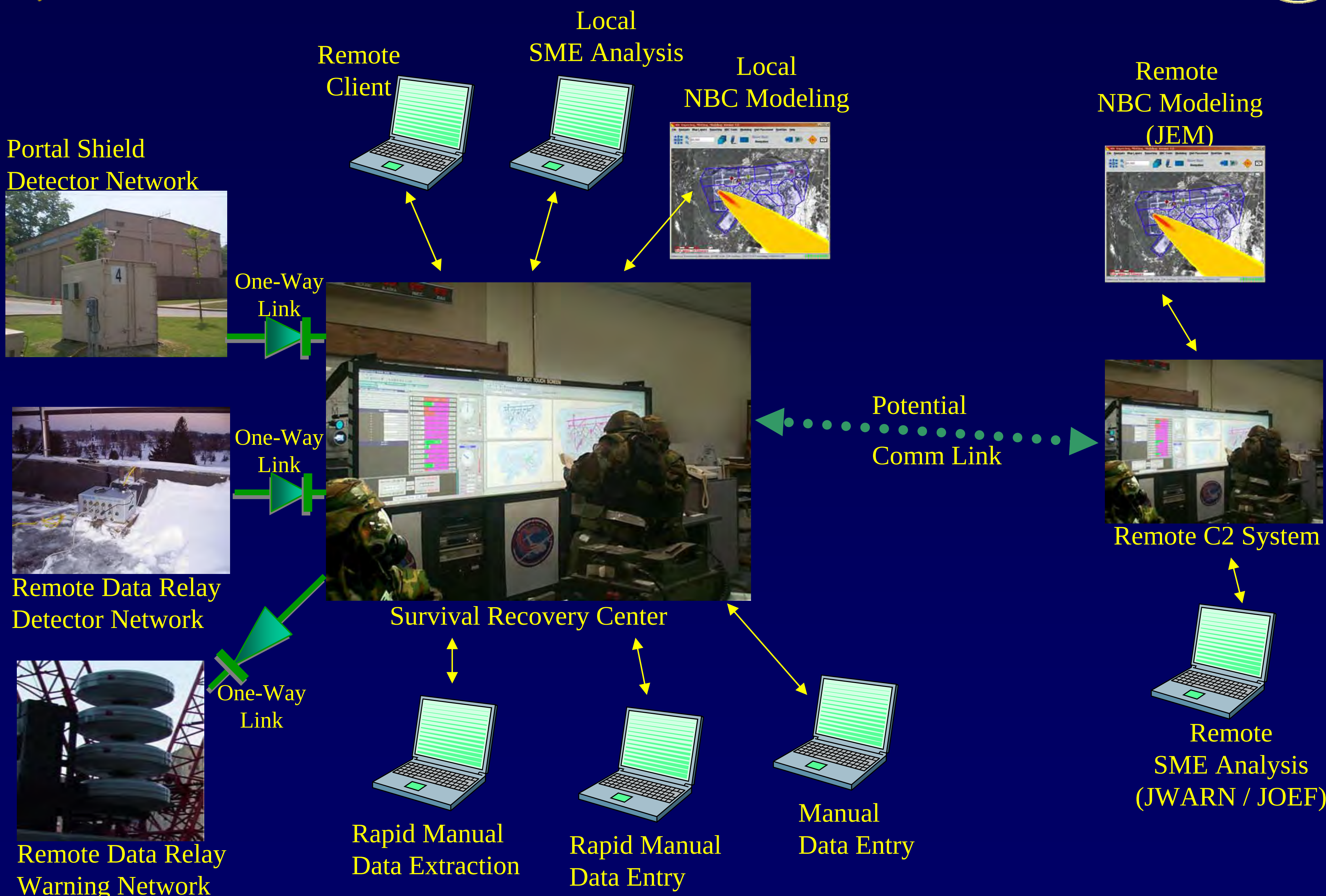
CBRN Information Management

- Capture the information in a format you can process
- Experienced humans appear to assume or skip steps – but the steps are accomplished
  - Build all the steps into your Battle Management System
- Automated systems tend to have hard coded steps – system can’t adapt
  - Design automated systems to be adaptive
- Regardless of how the change in state is initiated, change must be in a standard format and subject to a standard process
- Non-CBRN Information Management is the same
  - Intel

Outline

- Overview of CBRN Battle Management
  - Battle Management Decision Loop
  - CBRN Data Model
  - NGCBBM Decision Loop
- Examples of CBRN Information Management
  - Sensor / Actuator interaction
  - Analysis and assessment
  - Status
  - Response plans
- Examples of Operational Environment System Configuration
  - Data Acquisition
  - Operation Across Guards
  - Multi-level Data Processing
- Conclusions

Chem/Bio Battle Management



Multiple Level Security Networks

- Multiple Networks
  - Detector
  - Local C2
  - Higher Level C2

- Network Links
  - Detector to Local C2
    - Fat Finger
    - Sneaker Net
    - One-way Fiber

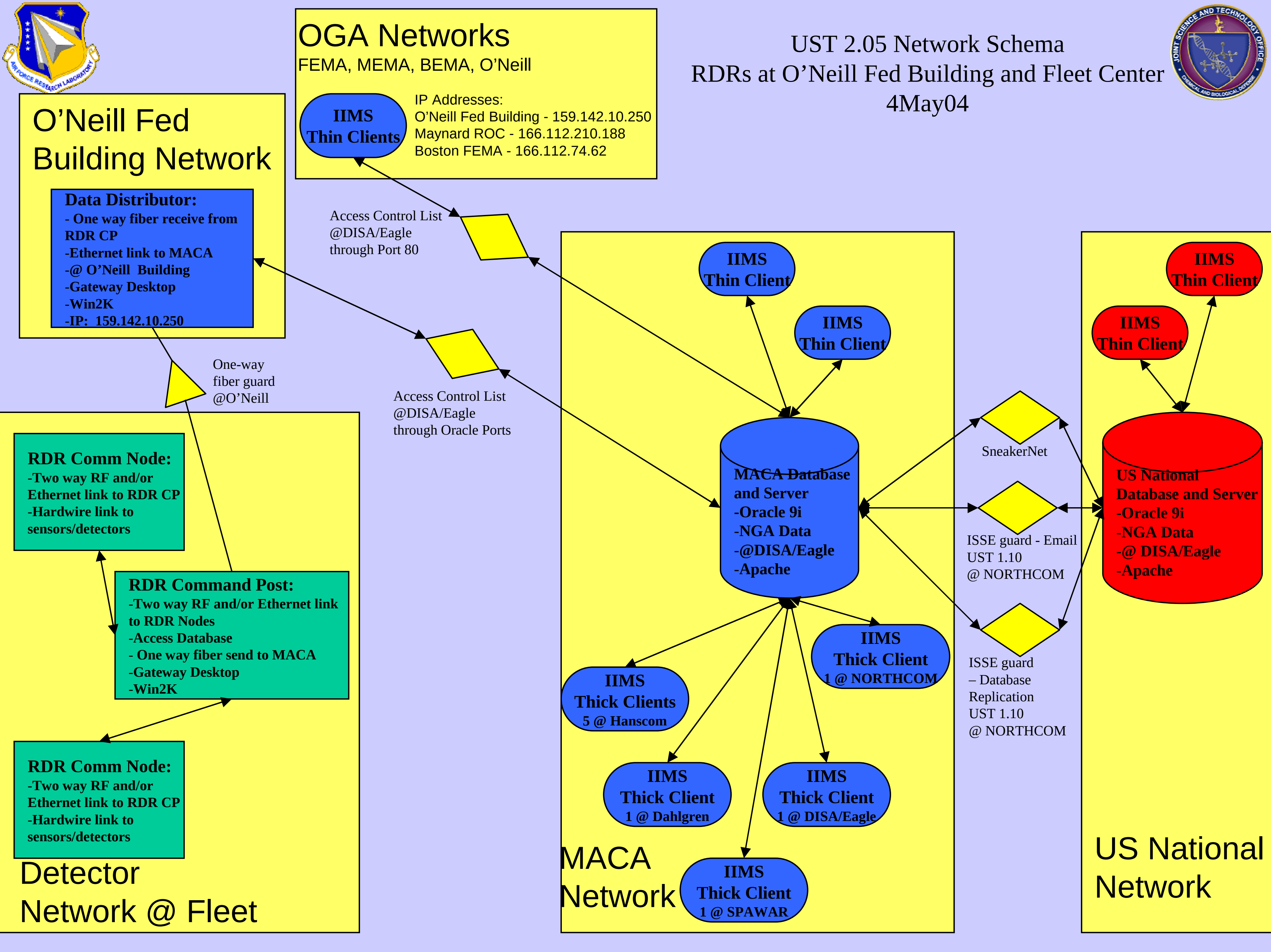
  - LAN C2 to WAN C2
    - Fat Finger
    - Sneaker Net
    - Database replication through ISSE and other Guards
      - Classification rules?

Network Centric Operations

- Stand Alone Client
- LAN
  - EARs
  - Shared Map Layers
  - Shared Database
- Multiple WANs
  - Common Message Parser and Email
  - CBRN Messages
  - Common Alerting Protocol
  - USMTF
  - XML

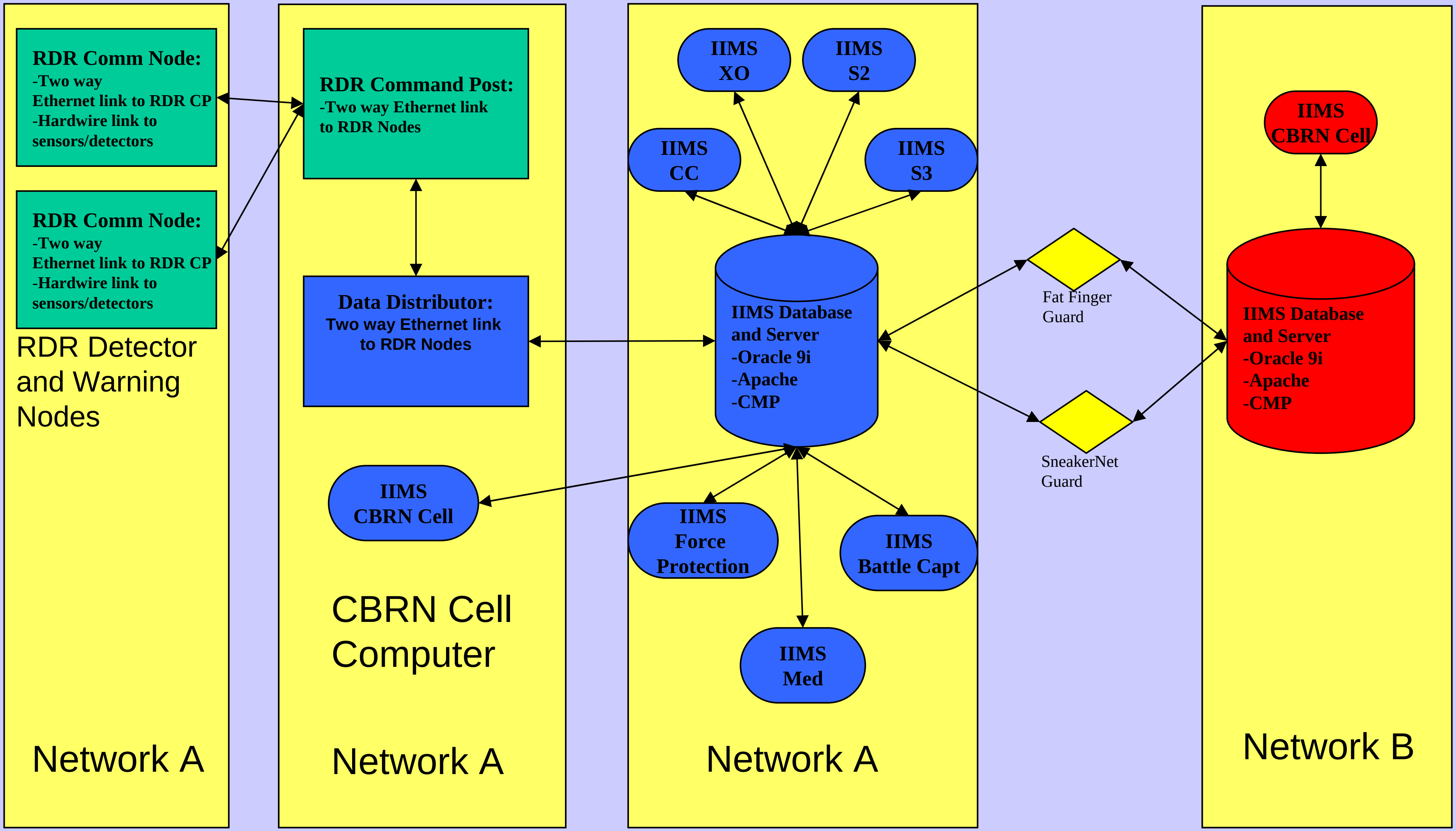
Network Dependency of Mission Critical Systems

- Network Centric is Great
- Network Dependent is Network Vulnerable
- A local system must continue to operate when the network doesn’t
- Information must be processed on different security level networks
  - Information Objects must include a WWID with a MAC address and history of changes

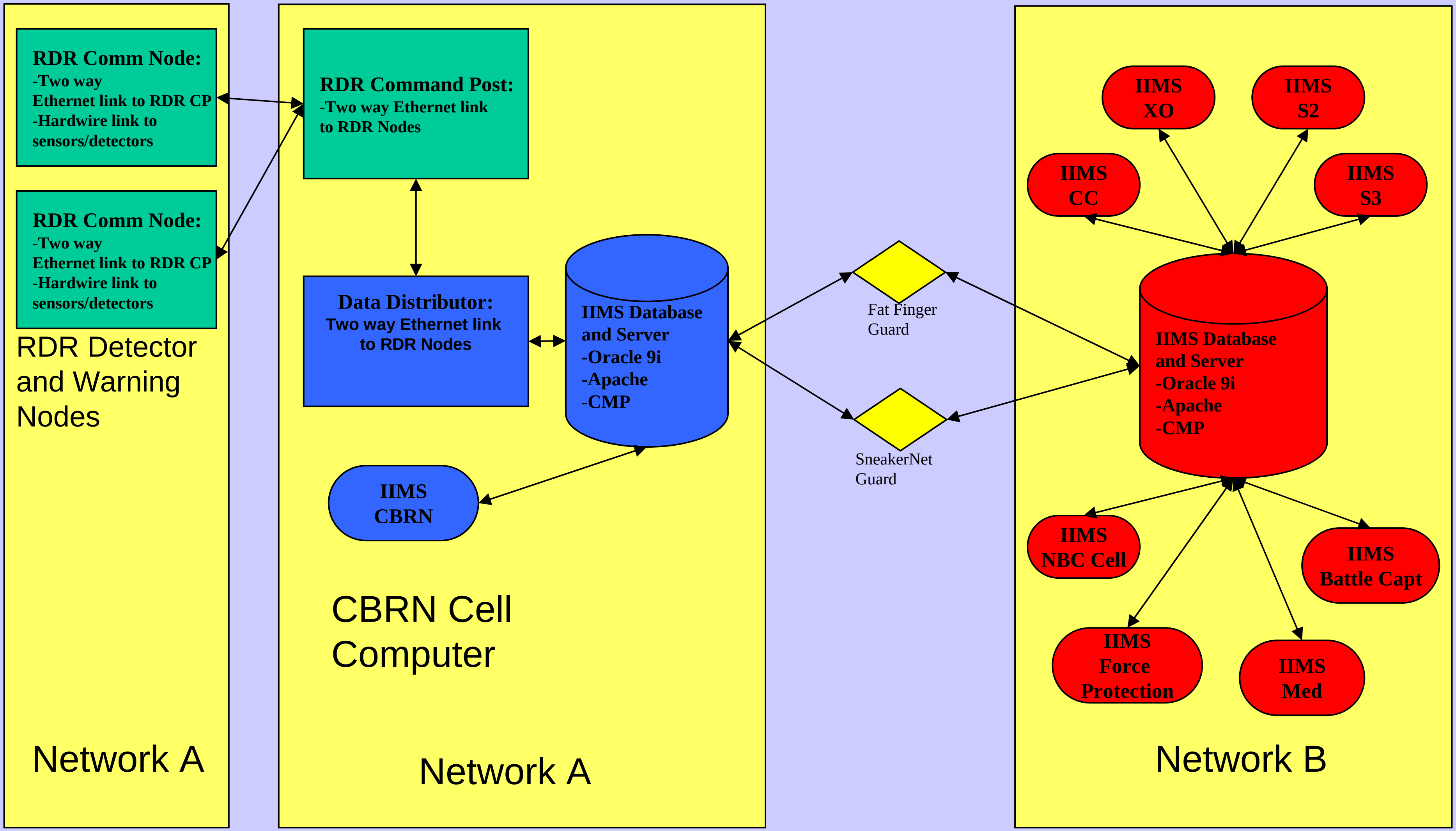

UST 2.05 Network Schema
RDRs at O'Neill Fed Building and Fleet Center
4May04
OGA Networks
FEMA, MEMA, BEMA, O'Neill
IIMS Thin Clients
IP Addresses:
O'Neill Fed Building - 159.142.10.250
Maynard ROC - 166.112.210.188
Boston FEMA - 166.112.74.62
O'Neill Fed Building Network
Data Distributor:
- One way fiber receive from RDR CP
-Ethernet link to MACA
-@ O'Neill Building
-Gateway Desktop
-Win2K
-IP: 159.142.10.250
Access Control List @DISA/Eagle through Port 80
Access Control List @DISA/Eagle through Oracle Ports
One-way fiber guard @O'Neill
RDR Comm Node:
-Two way RF and/or Ethernet link to RDR CP
-Hardwire link to sensors/detectors
RDR Command Post:
-Two way RF and/or Ethernet link to RDR Nodes
-Access Database
- One way fiber send to MACA
-Gateway Desktop
-Win2K
RDR Comm Node:
-Two way RF and/or Ethernet link to RDR CP
-Hardwire link to sensors/detectors
Detector Network @ Fleet
IIMS Thin Client
IIMS Thin Client
MACA Database and Server
-Oracle 9i
-NGA Data
-@DISA/Eagle
-Apache
IIMS Thick Client 1 @ NORTHCOM
IIMS Thick Clients 5 @ Hanscom
IIMS Thick Client 1 @ Dahlgren
IIMS Thick Client 1 @ DISA/Eagle
IIMS Thick Client 1 @ SPAWAR
MACA Network
SneakerNet
ISSE guard - Email UST 1.10 @ NORTHCOM
ISSE guard – Database Replication UST 1.10 @ NORTHCOM
IIMS Thin Client
IIMS Thin Client
US National Database and Server
-Oracle 9i
-NGA Data
-@ DISA/Eagle
-Apache
US National Network

IWARN Test Schema A

24 Oct 2005



IWARN Test Schema B
24 Oct 2005



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  - Multi-level Data Processing
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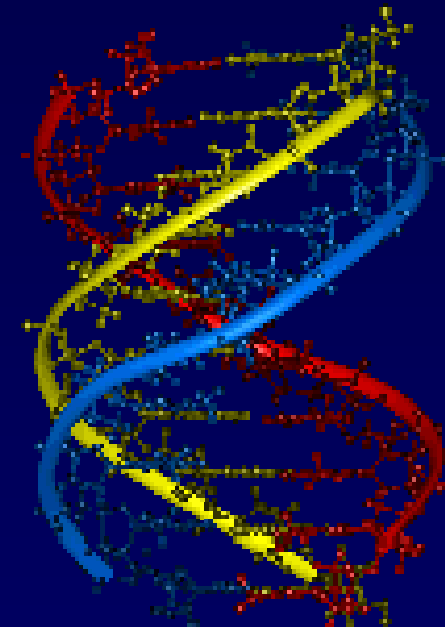
Adoption of the CBRN Data Model

- Does it support all CBRN information management steps?
  - What types of information management can the applications using the C2IEDM data model do now?
- Does it support all CBRN network configurations?
  - What network configurations can the C2IEDM data model support now?
- How do we transition to the CBRN Data Model?
  - Tailor model?
  - Tailor code?
  - Both?

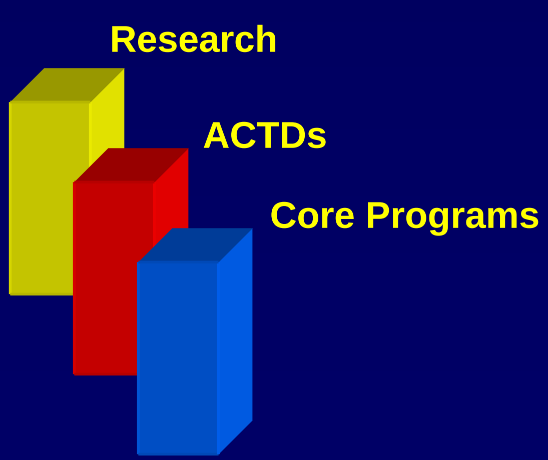
Transitioning Technology to the Warfighter

(Parallel Spiral Development)

- Create a Receptive host for Tech Transition
  - Provide a C2 Backbone for researchers to build against
  - Integrate mature IT products using ACTDs
  - Technically and Operationally Test concepts for Military Utility
  - Transition to either Core Programs or existing Battle Management Systems



- Field technology, solutions, and CONOPs
  - Build on success
  - Add components
  - Provide blue print for NBC Battle Management
  - Generalize the solution to address joint CONOPS
  - CONOPS and Technology leapfrog



Development and Implementation of a Model for Predicting the Aerosolization of Agents in a Stack

Teri J Robertson, Douglas S Burns, Jeffrey J Piotrowski, Dustin B Phelps, Veeradej Chynwat and Eileen P Corelli

ENSCO, Inc.

Science and Technology for Chem-Bio Information Systems (S&T CBIS)

October 28, 2005

Outline

- Project Goals
  - Account for aerosol formation in EMIS scenarios
  - Implement results in atmospheric transport and dispersion and chemistry models
- The "Problem"
- Methodology
  - Aerosol formation algorithms
  - Model assumptions and limitations
  - Integration of STACK into EMIS
- Results
  - Model output
    - Example TEPO scenario
    - SLAM particulate results
- Model Sensitivity
  - Sensitivity Analysis
  - Physical property data
- Future Work

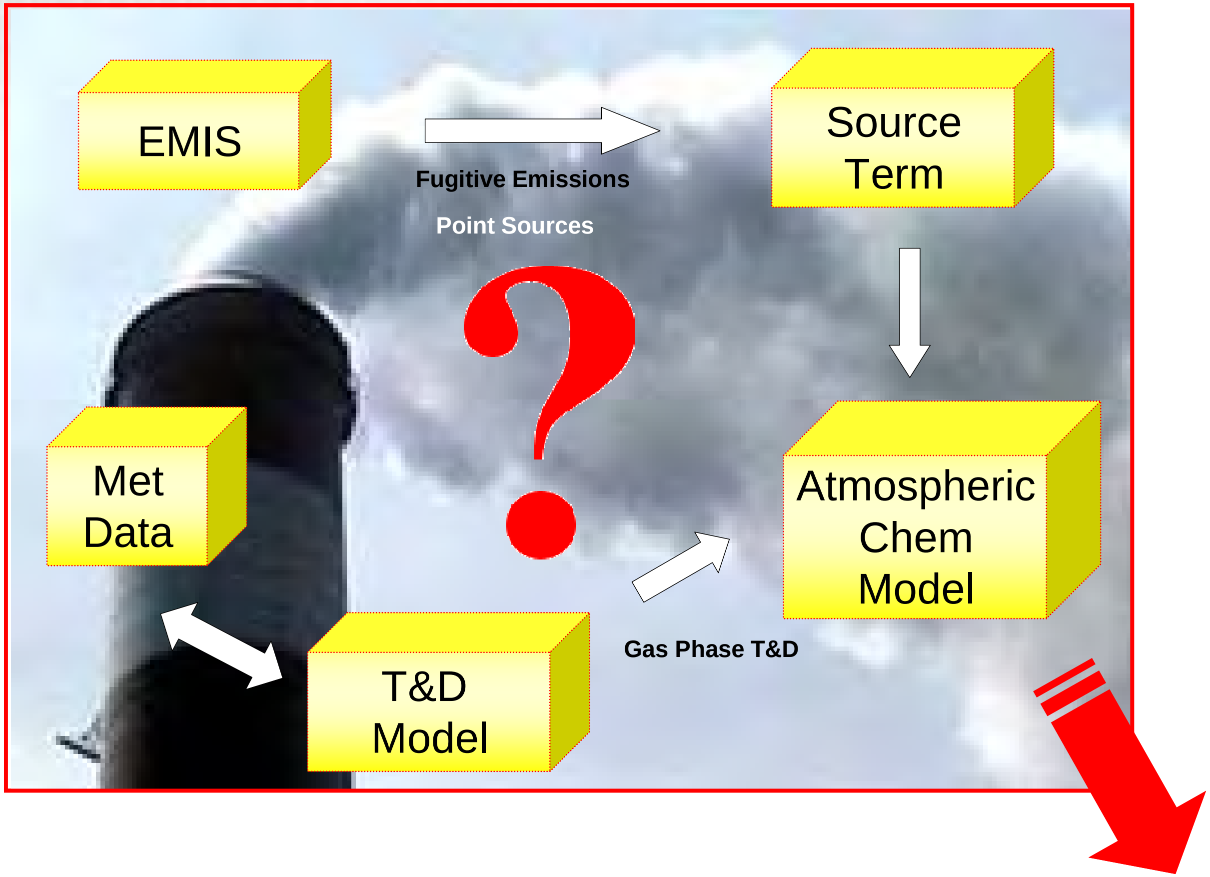
Project Goals

- **Adapt an aerosolization model**
  - Model must run rapidly
  - Code must be fairly “easy” to implement
  - Algorithms must handle streams with multiple components
  - Algorithm must be easily integrated with the EMIS (Emission Model for Industrial Sources) tool
  - Algorithm output must meet requirements for model input to AT&D (i.e., ChemCODE and SLAM)
- **Couple STACK model with EMIS**
- **Formulate output compatible with existing software suite**

The “Problem”

- Current model treats all emissions as gas phase
- Most OPs will condense to at least some extent at ambient conditions
- A TIC may condense at the stack and some may never even ‘see’ the transport and dispersion model!
- Result: overestimates downwind hazard prediction

The “Problem”



Downwind Hazard Prediction

Methodology: Governing Equations

$$\frac{\partial n_m}{\partial t} = r_A = -r_N - r_C$$

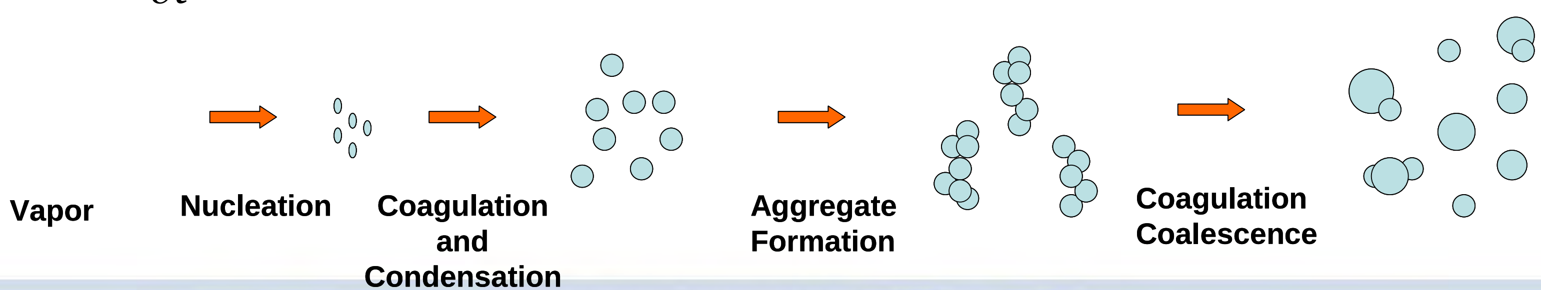
$$r_N = \frac{v_1}{\rho_g}\left[\frac{2\sigma}{\pi m_1}\right]^{\frac{1}{2}} n_{ms}^2 S \exp\left[\theta - \frac{4\theta^3}{27(\ln S)^2}\right] n^*$$

$$r_C = \left[n_m \rho_g \frac{u_m}{4} - n_{ms}\frac{u_m}{4}\right]\left[n_p \pi d_p^2\right] f(Kn)$$

$$r_F = 0.5\frac{\beta n_p{}^2 \rho_g}{W_s}$$

$$\frac{\partial n_p}{\partial t} = r_N - r_F$$

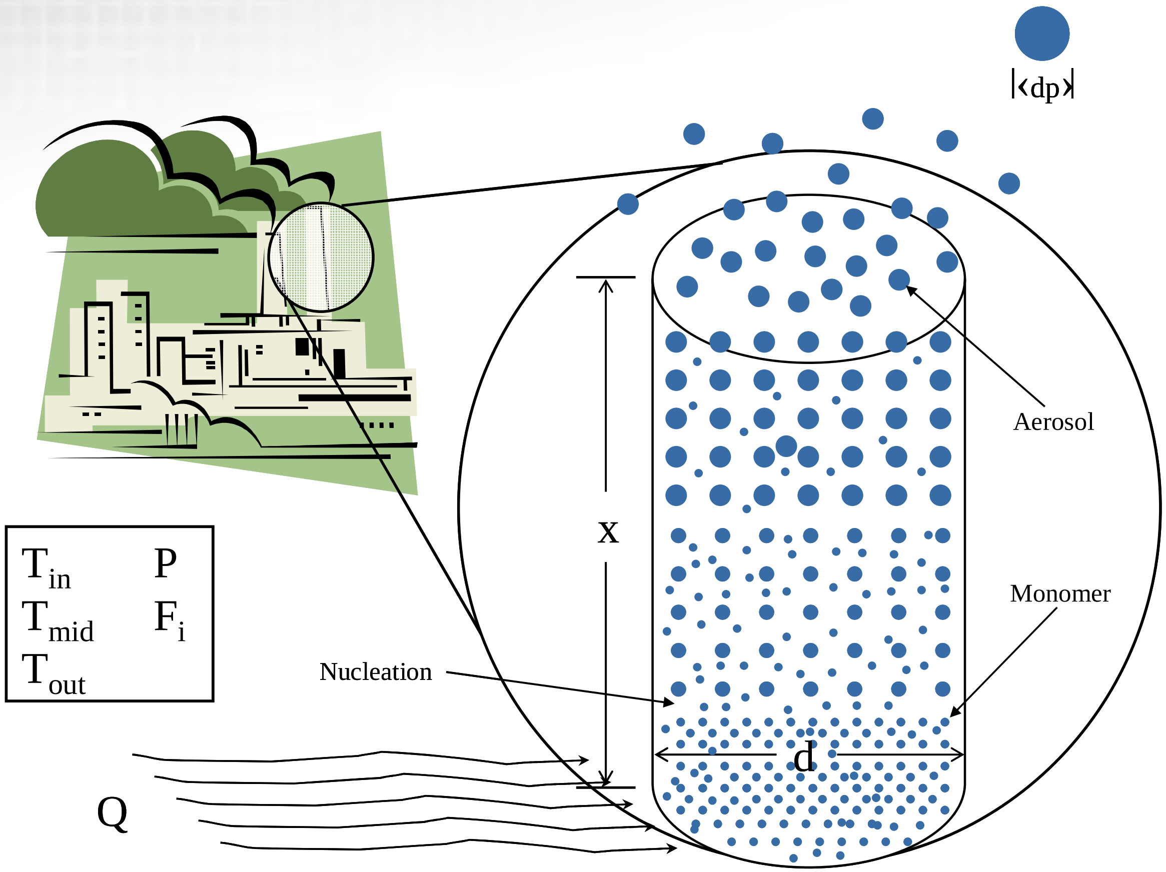
- Change in number of monomer molecules…rate of formation of particles of interest
- Nucleation = *f*(supersaturation ratio, surface tension, etc.)
- Critical nucleus size = point at which particles are stable (Gibbs)
- Coagulation = *f*(Knudsen, supersaturation ratio, flow regime)
- Flocculation = *f*(Number of particles, Knudsen)



Methodology:
Theoretical Model Assumptions/Limitations

- Single condensing component
- Ideal carrier density
- Neglects wall losses
- Produces an average particle diameter (monodisperse)
- Assumes no pair interaction potential between molecules during flocculation

The Stack Model



Methodology: Integration of STACK in EMIS

EMIS Output:
process stream and
thermodynamic information

↓

User selection
of stack
properties

↓

Physical properties
sort and
comparison

↓

Compound for
condensation
is selected

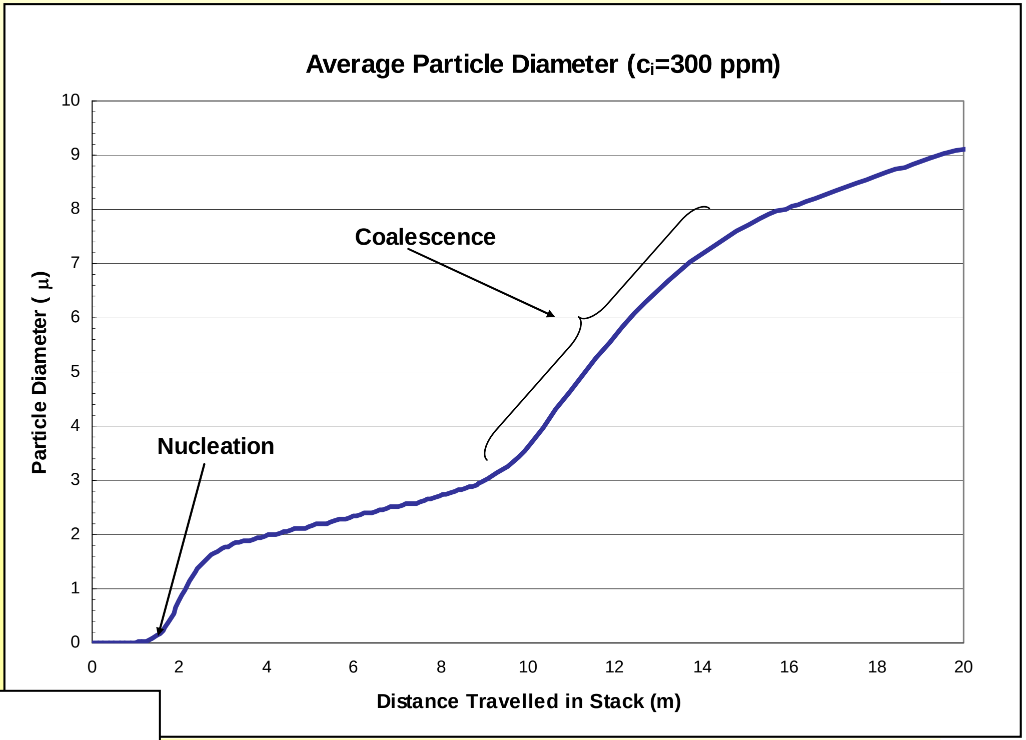
→

Physical property and
stack data passed
to STACK algorithm

→

LSODE run on
model produces
new n_m and d_p

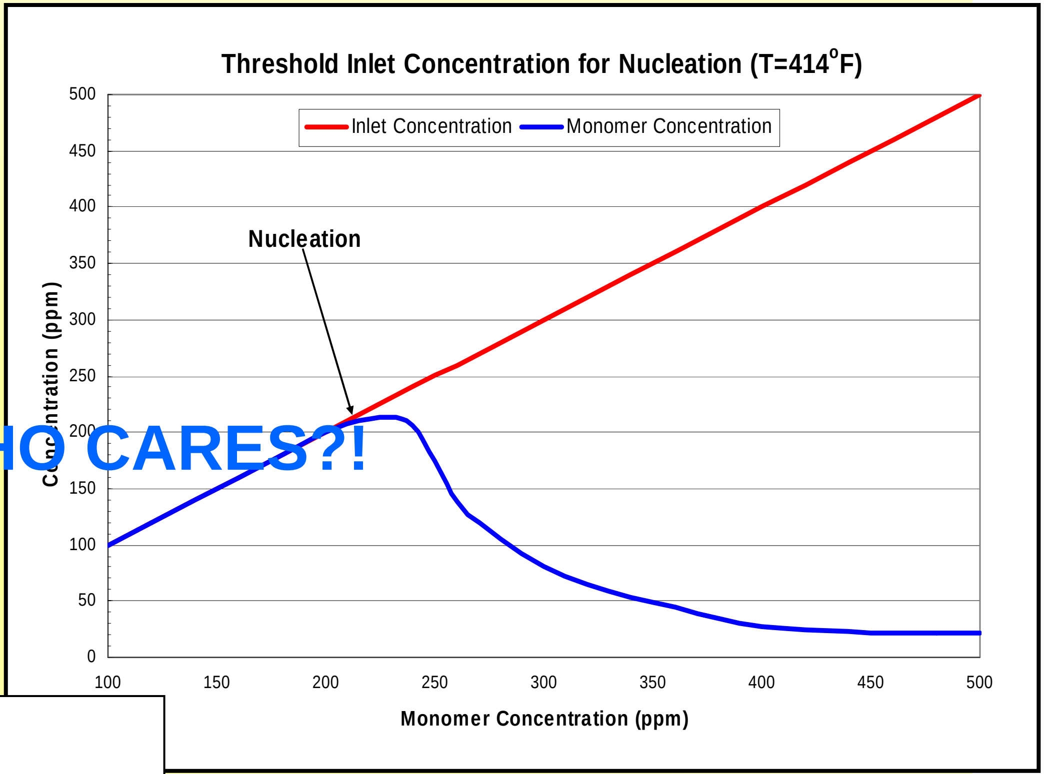
Results: TEPO Particle Size



Example: Parameters

- Compound: **TEPO (Triethyl Phosphate)**
- Carrier Gas: **Air**
- Boiling point: **419°F**
- Stack height: **20 m**
- Stack diameter: **0.3 m**
- Effluent Temperature: **404°F**
- Outlet Temperature: **350°F**

Results: Threshold Nucleation

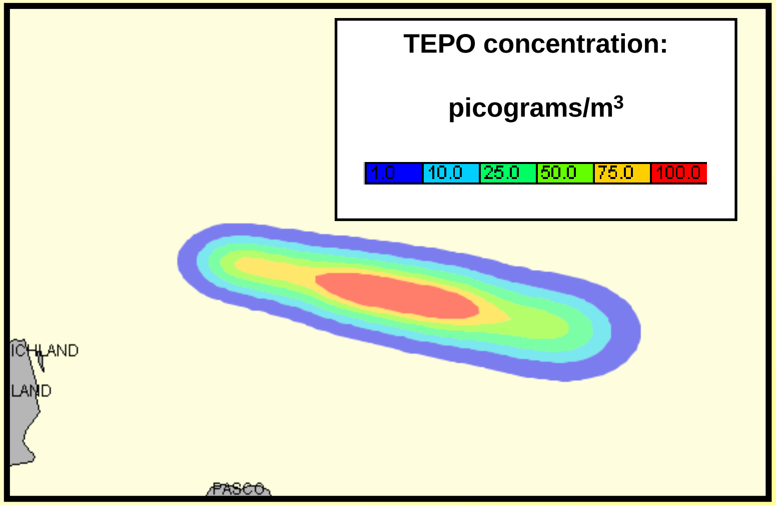


WHO CARES?!

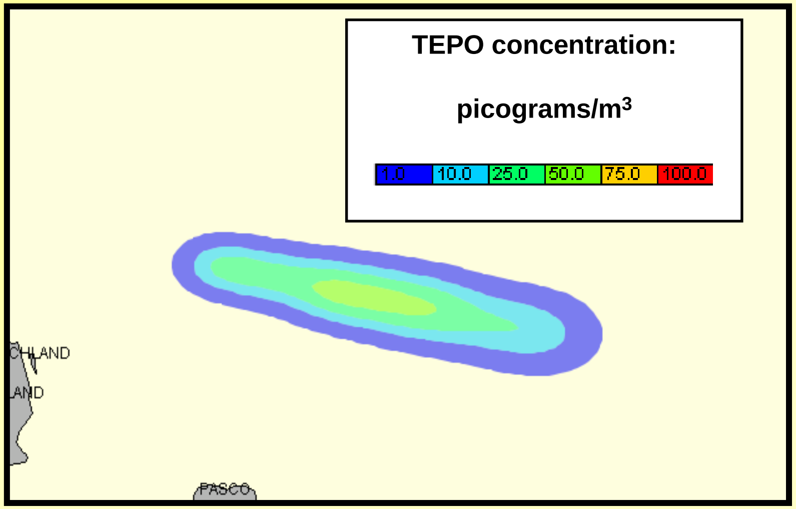
Example: Parameters

- Compound: **TEPO (Triethyl Phosphate)**
- Carrier Gas: **Air**
- Boiling point: **419°F**
- Stack height: **20 m**
- Stack diameter: **0.3 m**
- Temperature: **414°F**

Results: Example T&D Runs



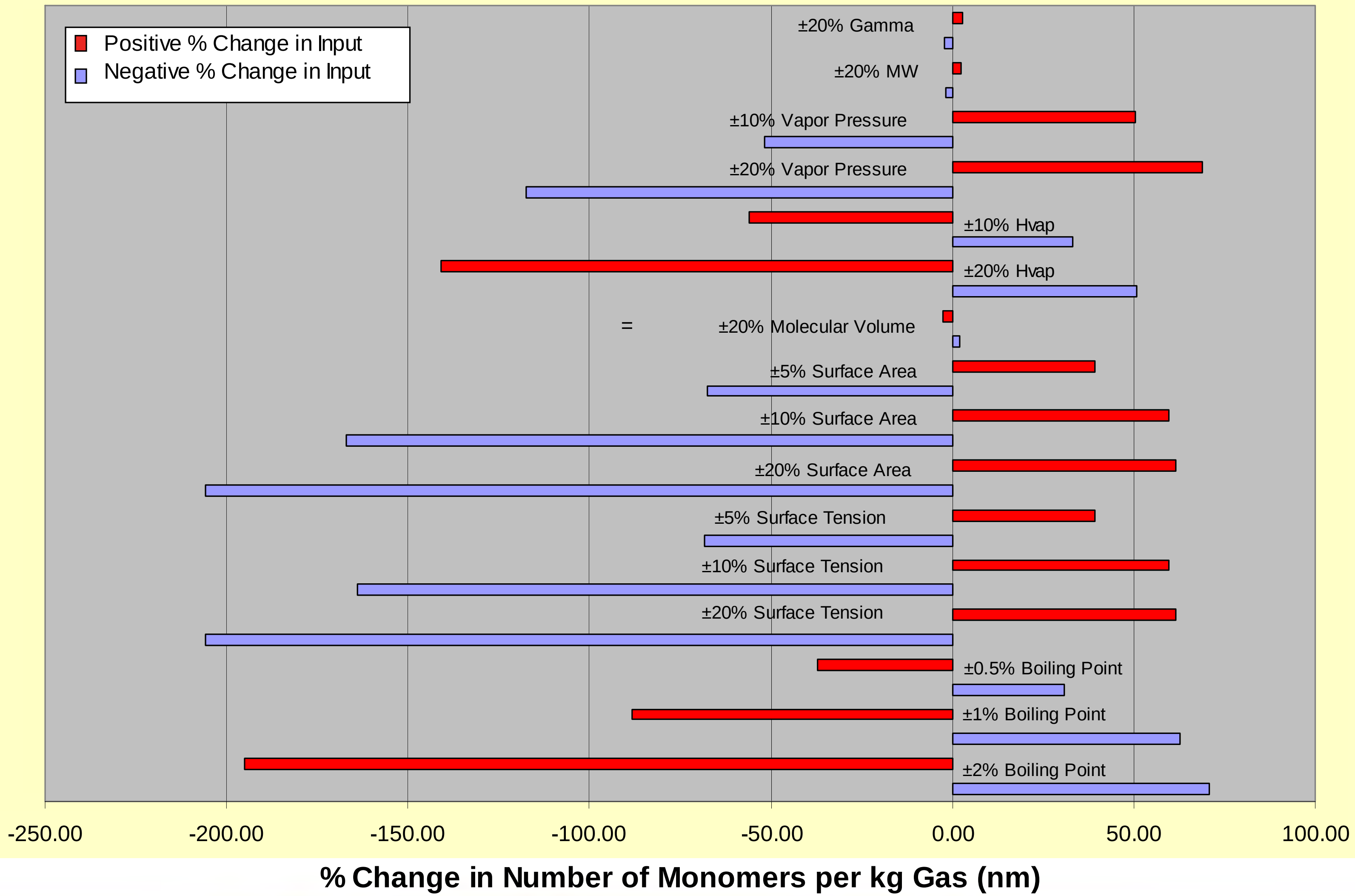
Gas Phase SLAM Run



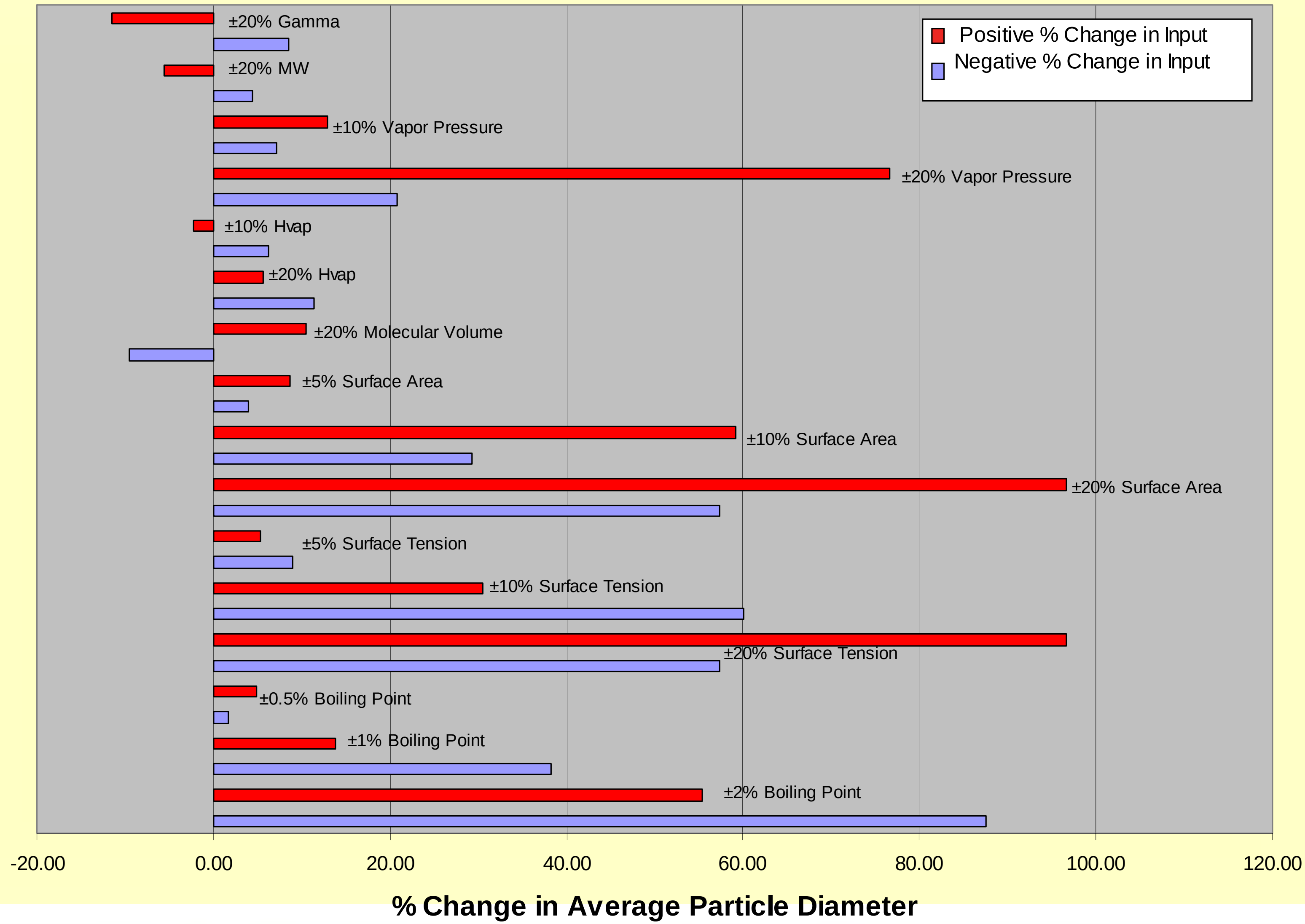
Particulate (d_p= 5μm) SLAM Run

8 hour release starting at noon local time: 1 kg/hr

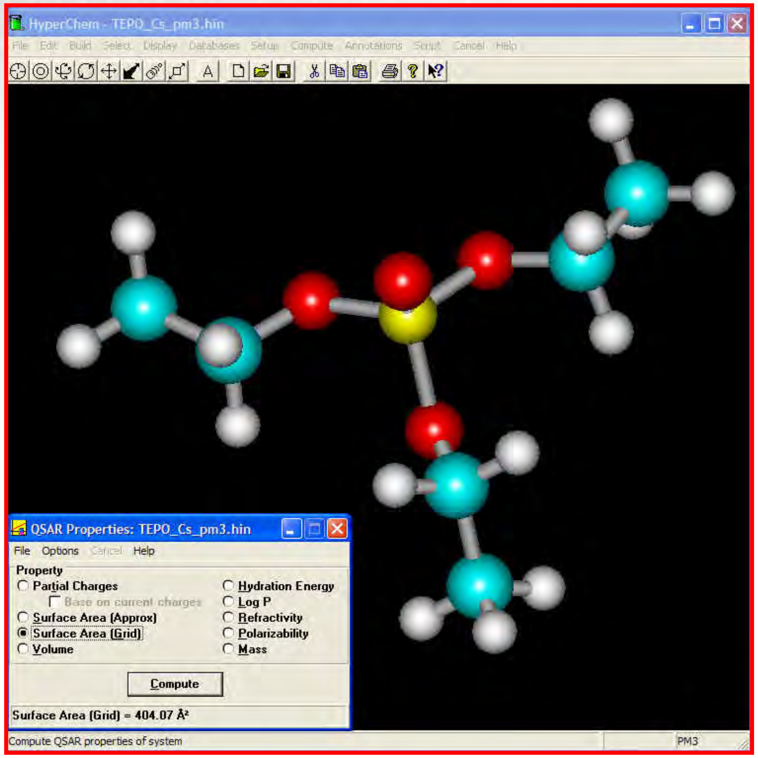
Model Sensitivity: Analysis, n_m



Model Sensitivity: Analysis, d_p

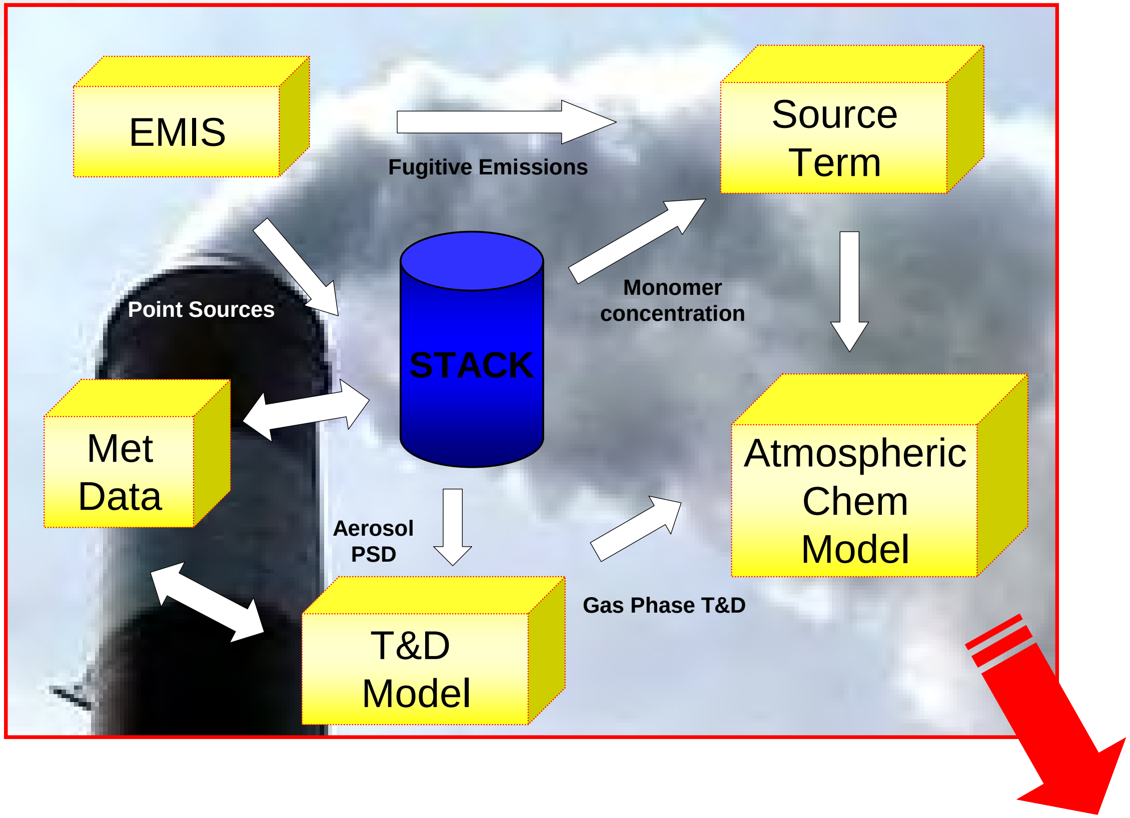


Model Sensitivity: Physical Property Estimation



- **Experimental and literature values**
- **ChemCAD physical property data and thermodynamic information**
- **Molecular surface area and volume estimated using molecular modeling tools (e.g. HyperChem, Gaussian)**
- **Physical property estimations (i.e., gamma from bulk stream viscosity)**
- **“SWAG”**

The Solution



Downwind Hazard Prediction

Future Work

- **Incorporate particle size distribution**
- **Improve handling of multicomponent effects**
- **Model verification and validation**
  - Literature
  - Field study data
  - Experimental data
- **Incorporate mixing effects outside the STACK**
  - Plume rise
  - CFD modeling

Questions?

Welcome

Dynamic Multi Sensor Management System



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1 November 2005

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Introduction

A Sensor Performance Data Management System is proposed to account for interaction of static and dynamic aspects of sensor performance.

This will support Battlespace Management of sensor networks by providing information of sensor performance at specific locations and times within an area of interest.

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Introduction

A Sensor Performance Data Management System is proposed to:

account for interaction of static and dynamic aspects of sensor performance.

This will support Battlespace Management of sensor networks by providing information of sensor performance at specific locations and times within an area of interest.

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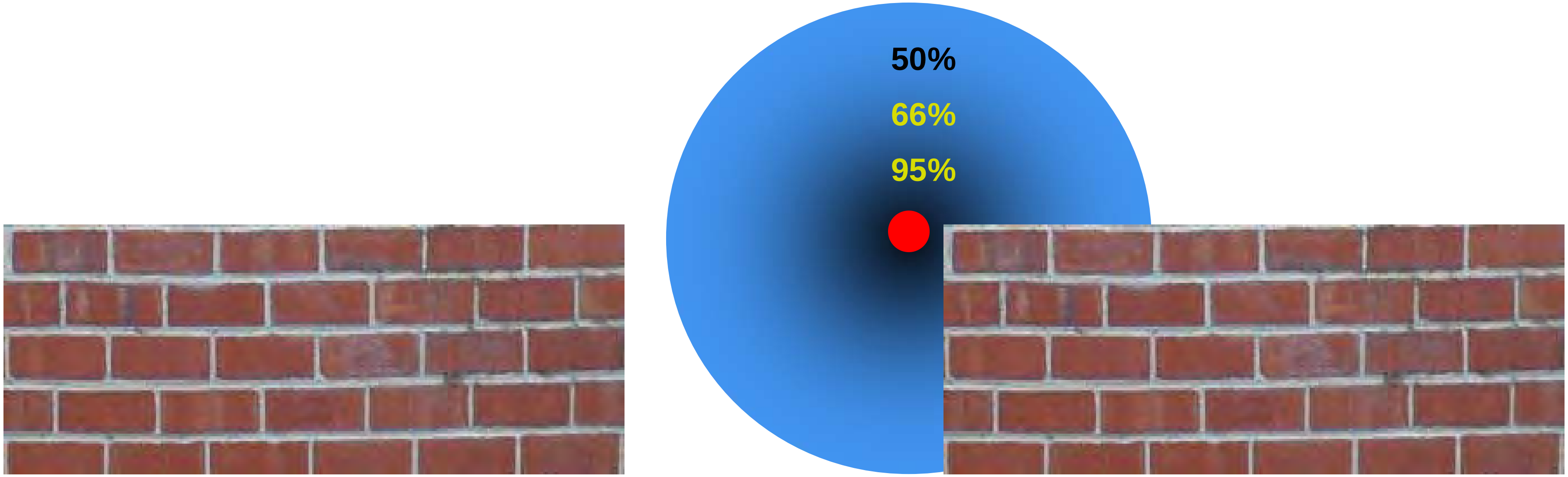
Multi Sensor Network To Protect Entry Gate

Each Sensor has a limited field of regard

Each Sensor has it's own unique performance contour



Chemical Sensor

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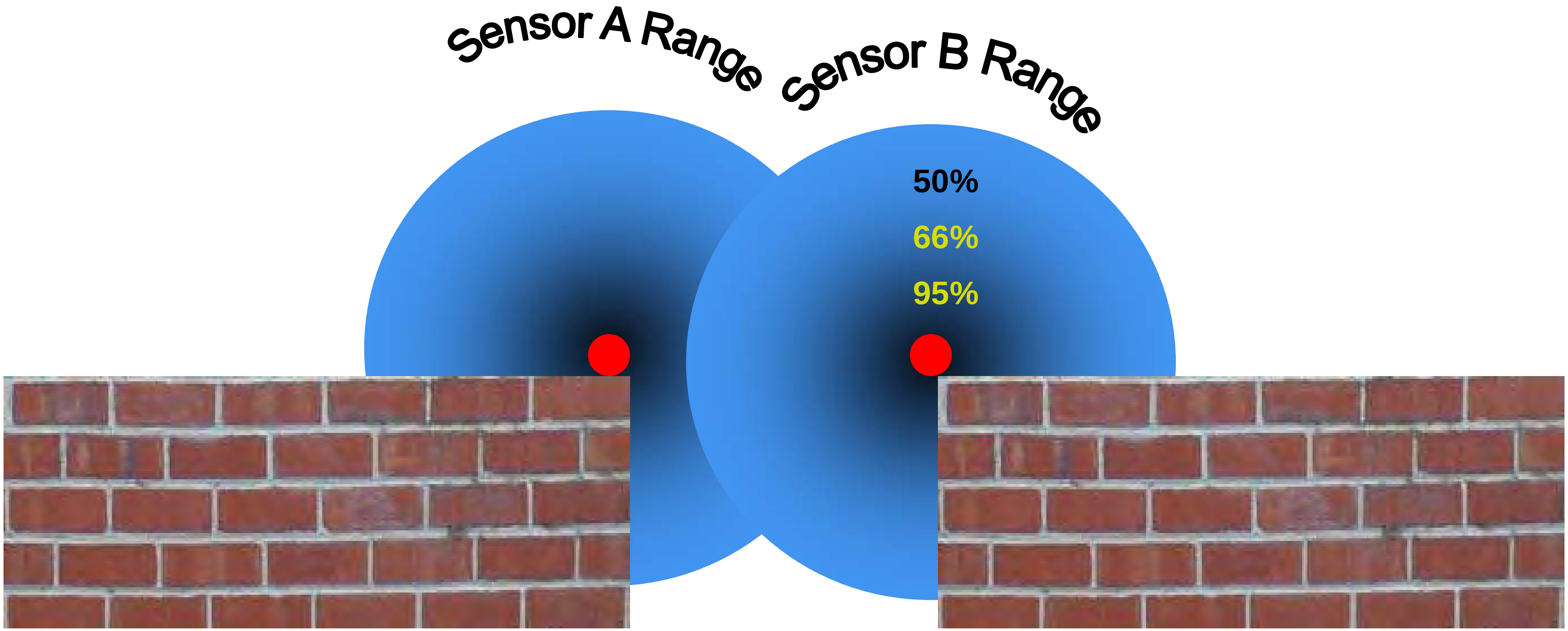
Multi Sensor Network To Protect Entry Gate

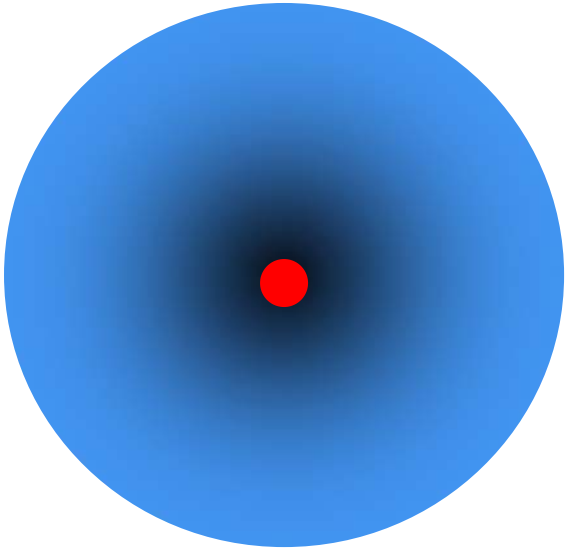
Each Sensor has a limited field of regard

Each Sensor has it's own unique performance contour



Performance Modeling Today

- Performance Modeling (PM) is often a single prediction as though sensor performance is uniform over an entire field of regard assuming
  - Worst Case
  - Average Case
  - Best Case



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Issues

- Sensor performance is inherently a spatially AND temporally variant quantity
  - A single performance prediction may be good ‘on average’, but poor at any particular location or time
  - What happens when a sensor is not operating within design limits?

Variables Effecting Sensor Performance

- **Environmental Issues**
  - Wind
  - Humidity
  - Lighting
  - Temperature
- **Sensor Issues**
  - Calibration state
  - Sensor health

Decision Maker Assumes Standard Operating Environmental Conditions

Data Flow

Sensor Network

Sensor Data
Metadata

Data Reduction & Fusion

Decision Maker

Alarm

No Alarm

Assumes standard conditions:

1. Environmental

2. Sensor State

The decisions are based on standardized operating conditions (nominal)

Actual Environmental Conditions

Data Flow

Sensor Network

Sensor Data

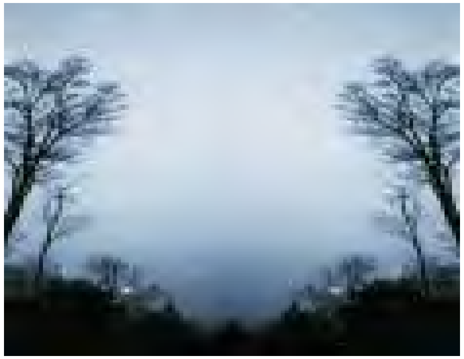
Metadata

Data Reduction & Fusion

Decision Maker

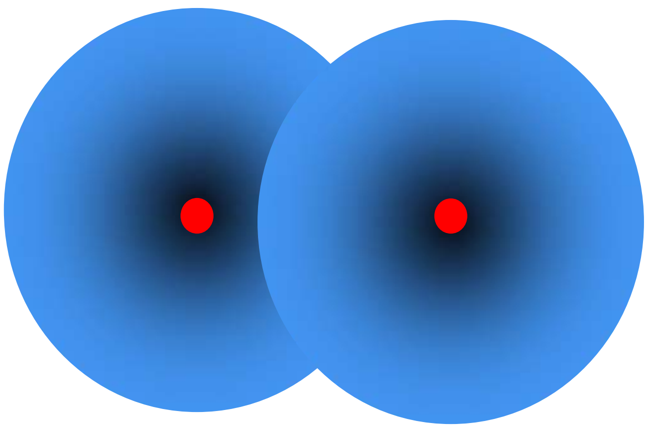
Alarm

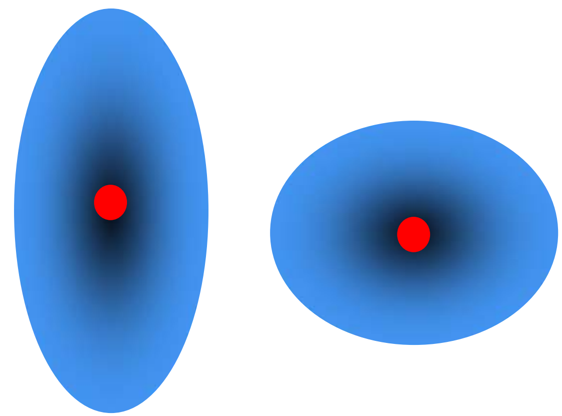
No Alarm



As standardized operating conditions vary, assumptions about sensor performance will change

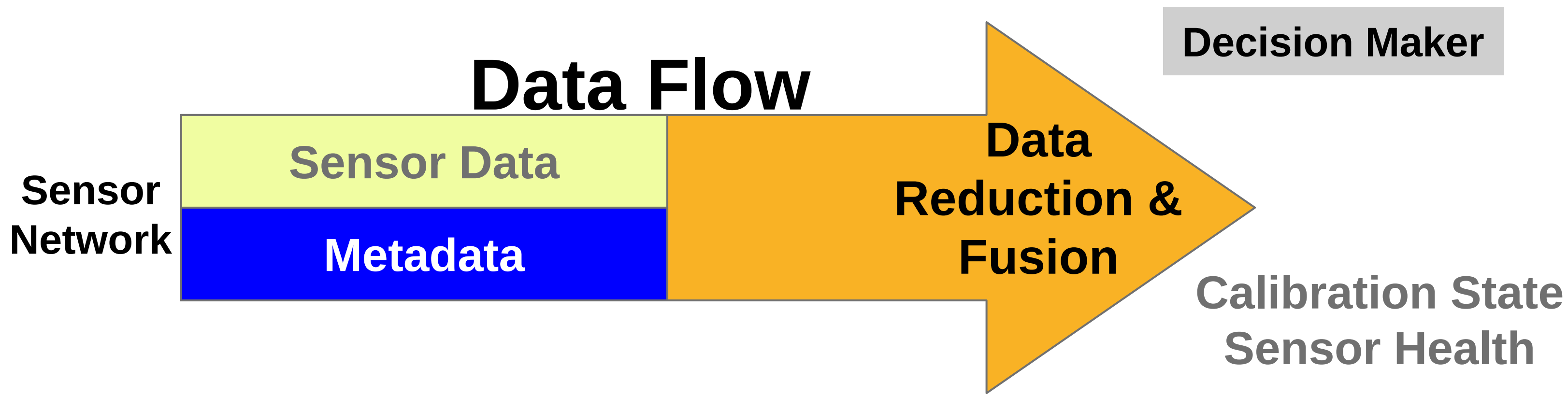
Sensor Coverage: Environmental Differences





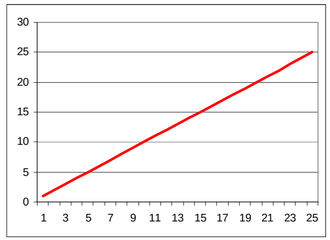
Sensor Operating Performance & Area Coverage

Sensor State Conditions

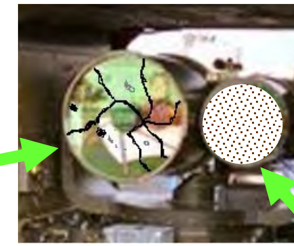


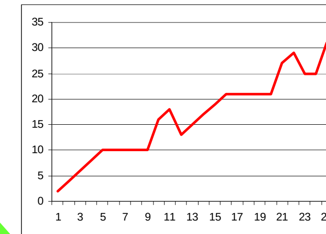
The decisions are based on standardized operating conditions (nominal)

Sensor State Coverage

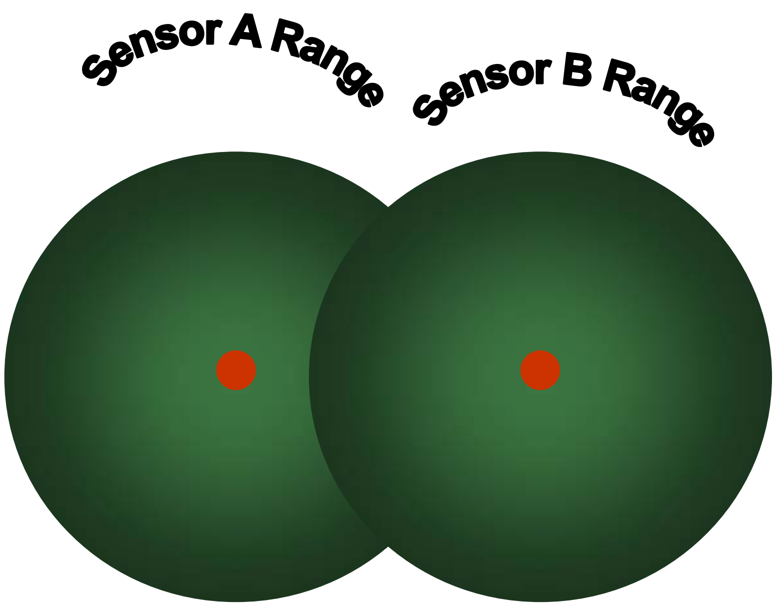


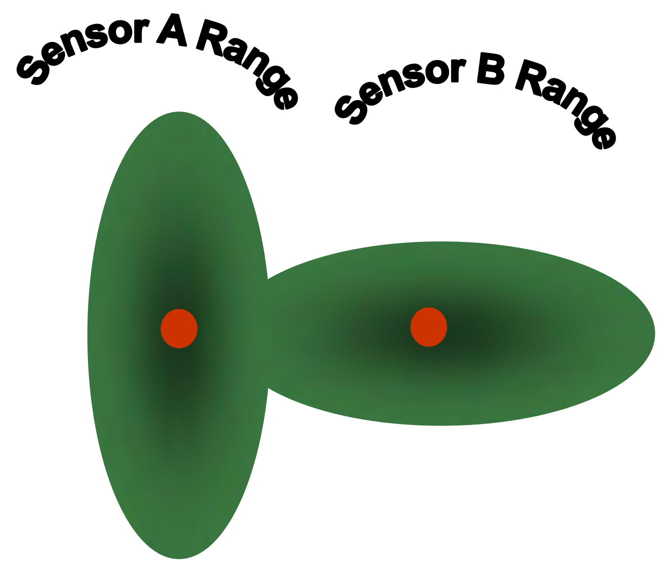
Lens cracks





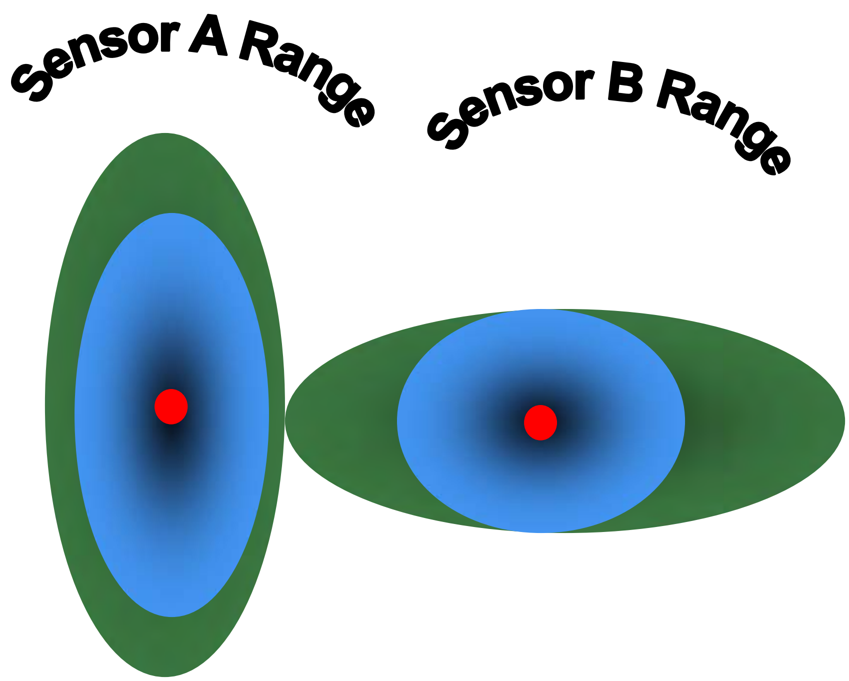
Dirty Window





Sensor State Operating Performance & Area Coverage

Combination of Environmental and Sensor State Contours



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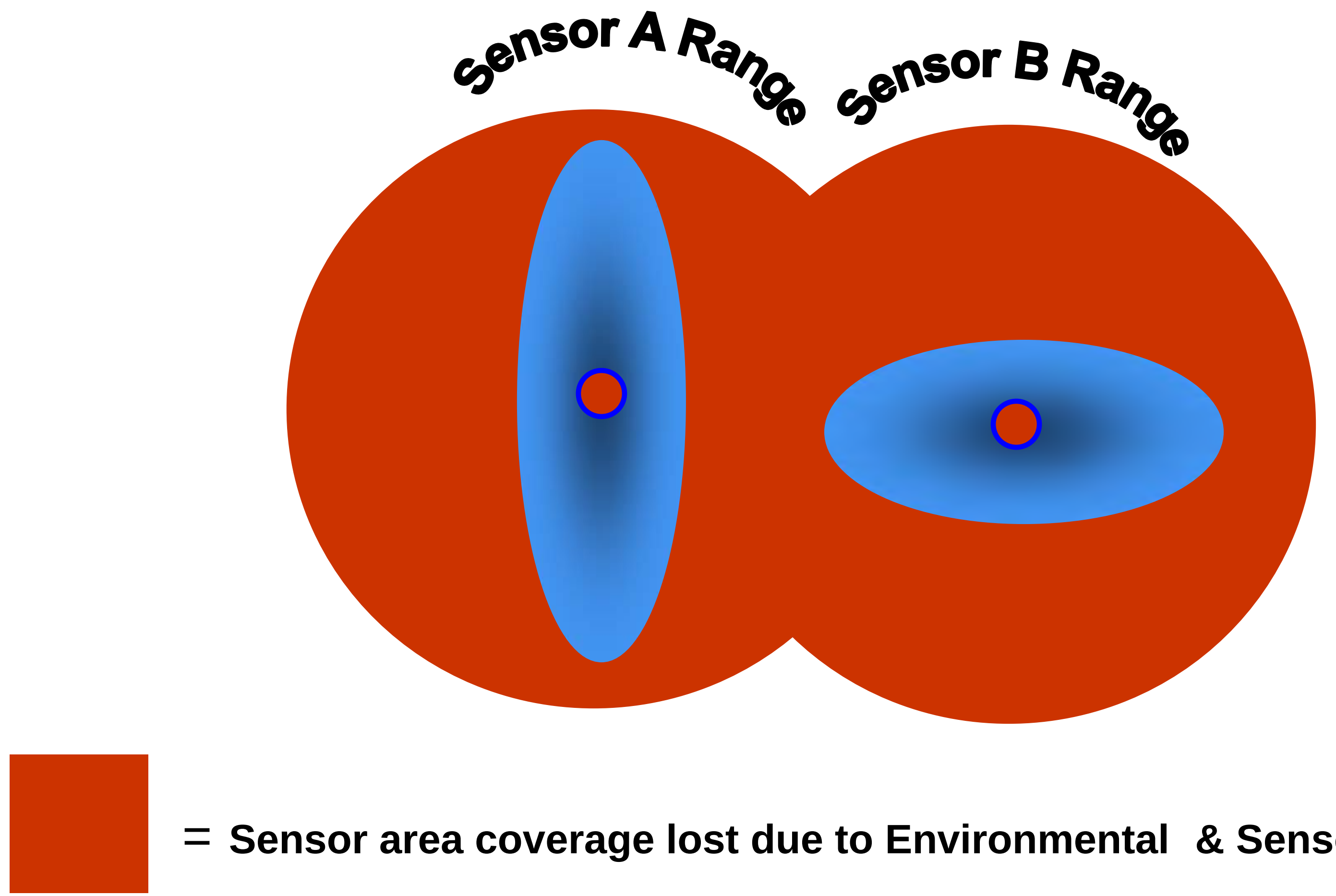
Sensor Area Coverage Lost from Nominal Conditions



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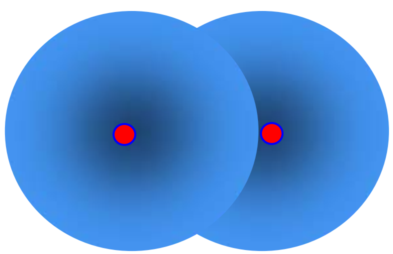
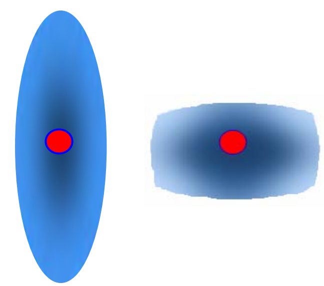
Solution: A Picture of Sensor Performance

Manage Sensor performance actively during operations of each sensor

Update as a function of location and time within the sensor field of regard





Sensor Performance Models

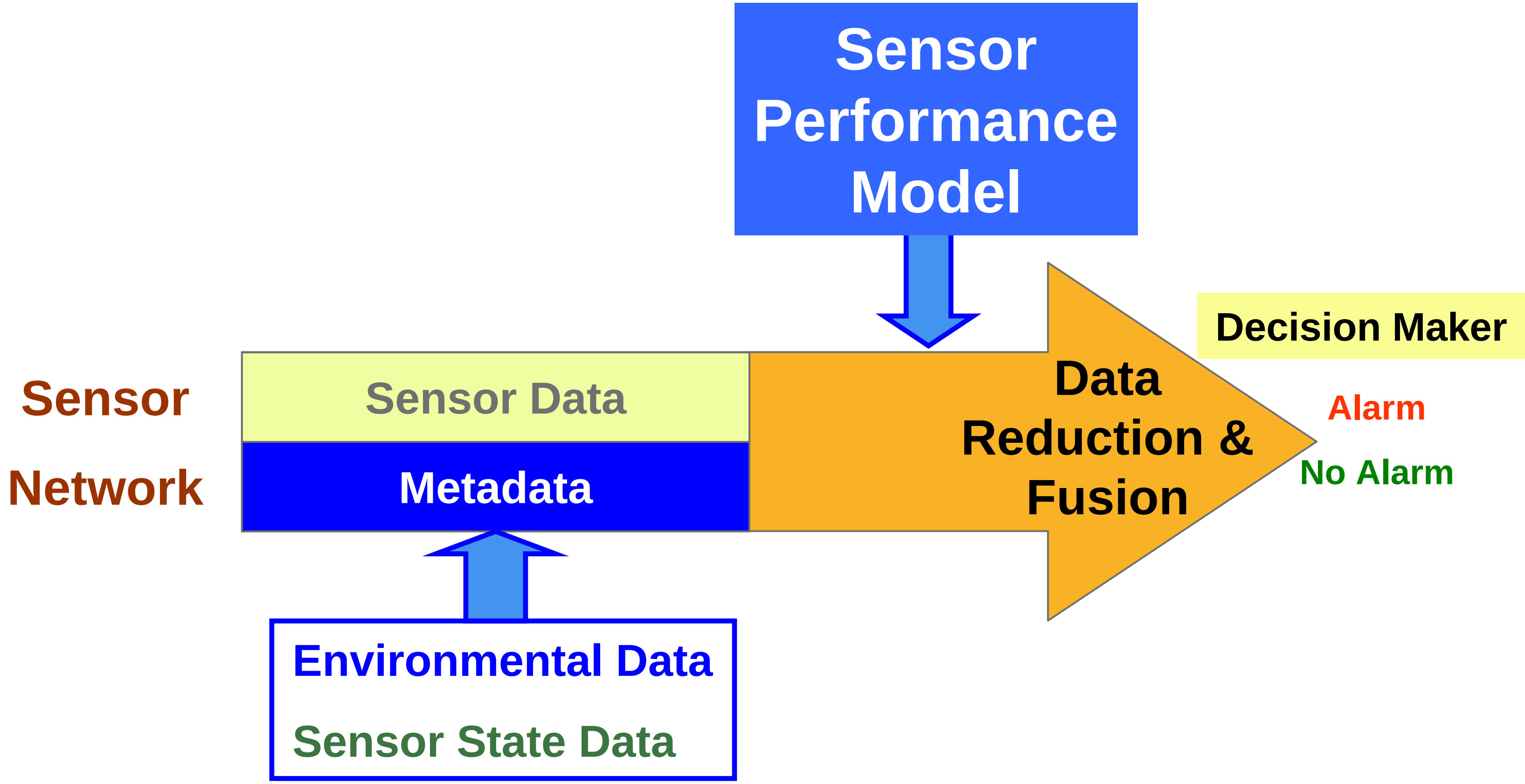
Sensor Performance Models are commonly used in sensor development and testing.

Examples:

– Chemical and Gas Sensing models include plume migration and wind effects as well as other important factors

– Imaging Sensor Models account for exposure, focus and atmospherics as well as other important factors

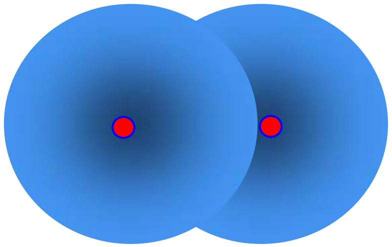
Solution: Insert Sensor Performance Model



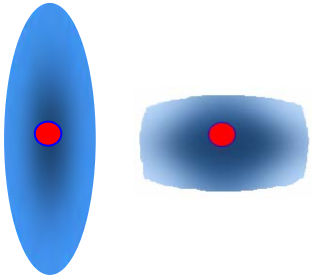
Insert Sensor Performance Model into operational architecture

Solution: Insert Sensor Performance Model

Is it this



Or this?

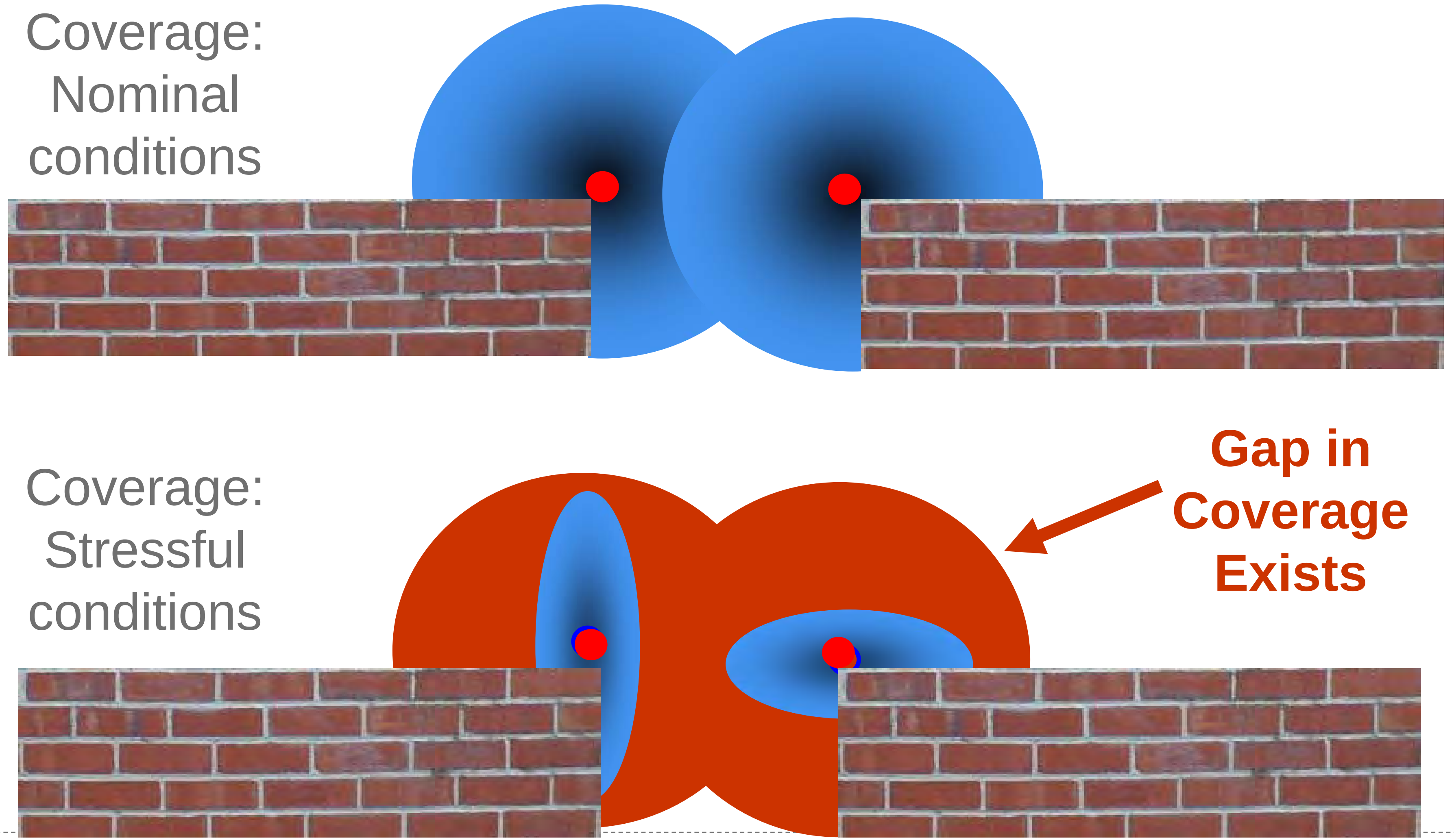


Sensor Performance Model → Evaluate Predictions Against Requirements → Confirm coverage **Or** Identify gaps

↓

Decision Maker

Predictions Evaluated Against Requirement



Near Real Time Threat Mitigation

Identify coverage gaps due to

- Changes in Environmental conditions
- Failed/degraded sensors

Answer the following questions

- Where coverage gaps?
- How big are they?
- Can I redeploy existing sensors to remove/reduce the gap?
- Where do I deploy additional sensors to fill gaps?

Threat Management Applications

Supports re-assessment of network capability during operations

Provides capability to assess performance against stressful operational scenarios

Allows Redesign of operational sensor networks

– New mission requirements
– Variable threat levels
– New/improved sensor technologies

Conclusion

Integration of the Sensor Performance Model into your operational sensor network will provide dynamic knowledge of the system performance at particular locations and times within an area of interest.

This benefits battlespace management by supporting:

Near Real Time Threat Mitigation

Threat Management Applications

ITT Sensor Performance Modeling Experience

Sensor Type	Application
Thermal	Night time and low light Target Detection and identification
Video	Target detection, identification and tracking
Multi-Spectral	Materials Detection and Identification, full color and false color imaging
Hyper-Spectral	Material and Chemical Agent Detection and identification.
IMS	Chemical Gas Detection
LIDAR	Solid and Gas Biological and Chemical Agent Detection

Agent Fate Program Overview

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26 October 2005

What Is The Objective Of The Agent Fate Program?

Improve model predictions of agent persistence

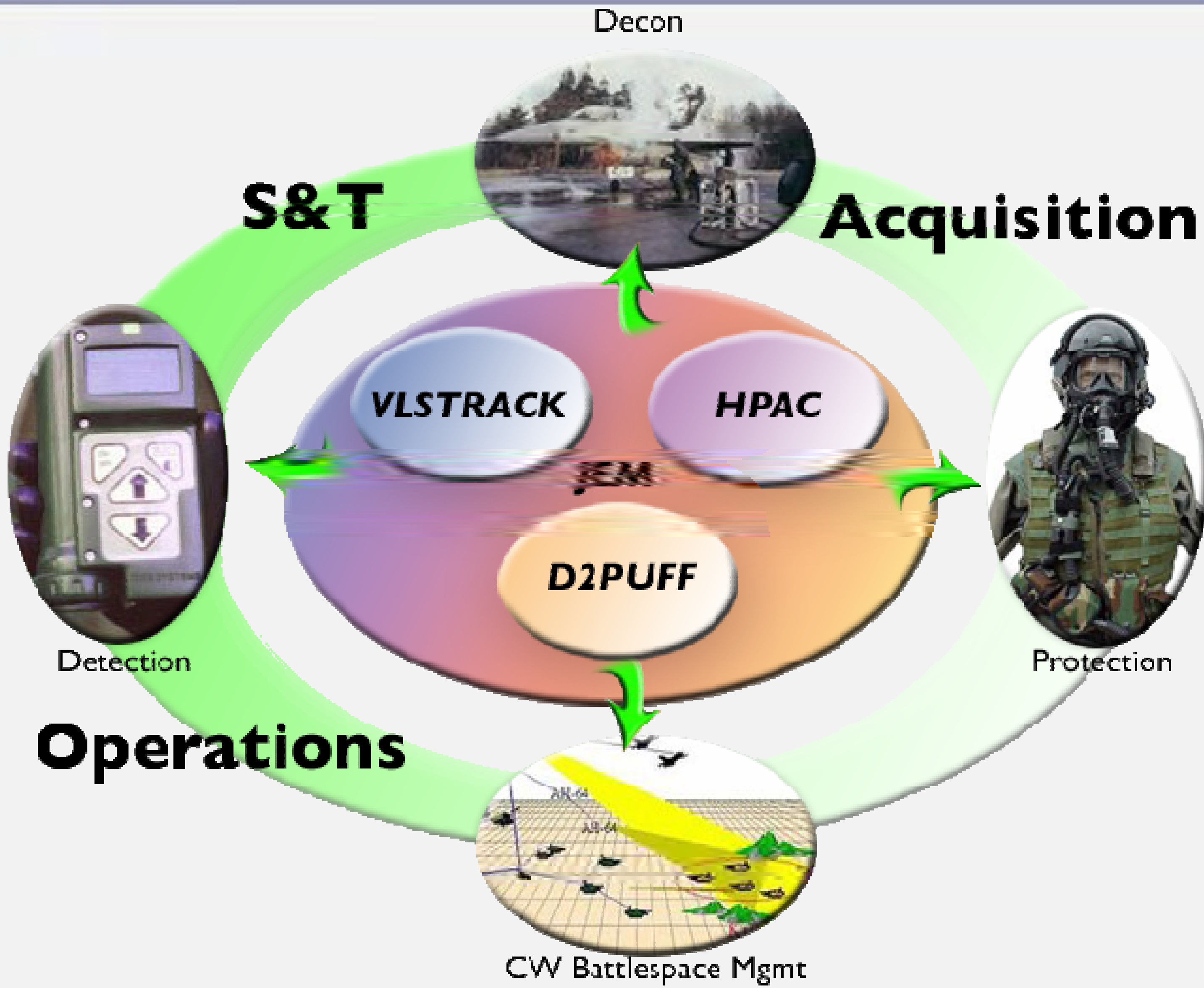
Objectives:

- **Measure and understand the physico-chemical processes of CW agents on surfaces in order to predict their persistence and fate in operational scenarios via agent fate models**

Payoffs:

- **Support research and acquisition decisions of all capability areas: detection, protection, decontamination**
- **Support and improve Operational Risk Management decisions based on inhalation and contact hazard**
- **JFOC - Battle Management: Battlespace Analysis and Planning**
- **Augments operational and mission area analysis tools such as Joint Effects Model (JEM) and Joint Operational Effects Federation (JOEF)**

Role of CB Hazard Models In ChemBio Defense Program



Why Do We Need An Agent Fate Program?

Models give varying and inaccurate persistence predictions

Field manuals and models built from limited data sets & questionable data

CONFLICTING

Concrete/Asphalt		FM 3-4		FM 3-3/ FM 3-7		FM 3-9		CONOPS	
	Temp	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor
GD	10-30ºC	Not Avail	Not Avail	Not Avail	Not Avail	Not Avail	Not Avail	< 0.2	.5 - 6
HD	10-30ºC	Not Avail	Not Avail	Not Avail	Not Avail	Not Avail	Not Avail	< 0.2	1 - 4.5
VX	10-30ºC	Not Avail	Not Avail	Not Avail	Not Avail	Not Avail	Not Avail	< 0.2	1 - 7.5

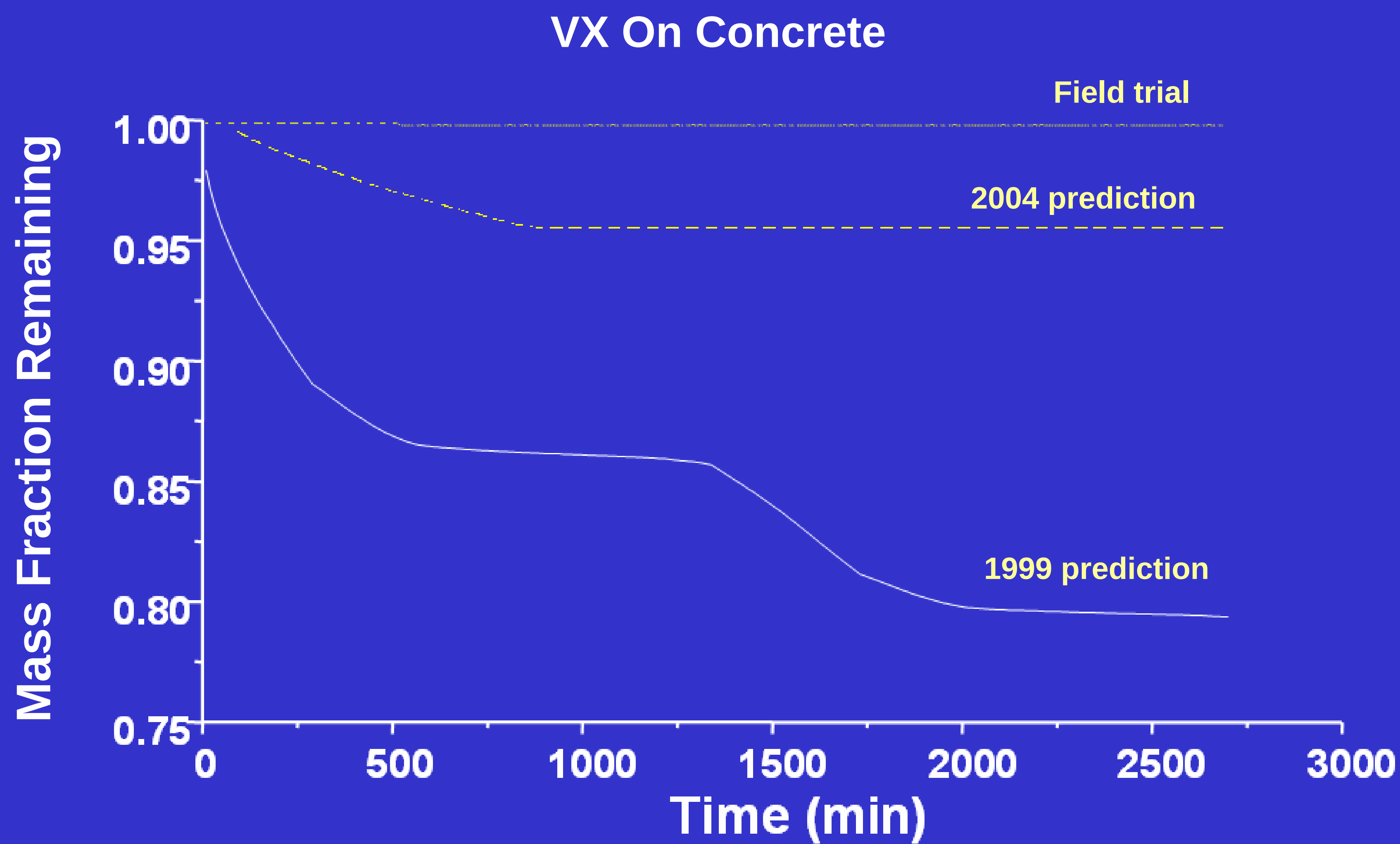
Sand		FM 3-4		FM 3-3/ FM 3-7		FM 3-9		CONOPS	
	Temp	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor
GD	10-30ºC	Not Avail	18 - 60+	Not Avail	11 - 44	Not Avail	5 - 48	< 0.2	.5 - 5
HD	10-30ºC	Not Avail	60+	Not Avail	3 - 12	Not Avail	6 - 168	< 0.2	.5 - 4
VX	10-30ºC	Not Avail	45 - 60+	Not Avail	1085 -7992	Not Avail	1800 -3600	< 0.2	7.5 - 10

Grass		FM 3-4		FM 3-3/ FM 3-7		FM 3-9		CONOPS	
	Temp	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor
GD	10-30ºC	Not Avail	7 - 20+	Not Avail	4-17	Not Avail	5 - 48	4*	.5 - 5
HD	10-30ºC	Not Avail	20+	Not Avail	1 - 5	Not Avail	6 - 168	4*	.5 - 4
VX	10-30ºC	Not Avail	18 - 20+	Not Avail	422 -3108	Not Avail	1800 -3600	4*	7.5 - 10

Temp 10-30 C	FM 3-4 Liquid	FM 3-4 Vapor
GD	Not Avail	7 - 20+
HD	Not Avail	20+
VX	Not Avail	18 - 20+

Temp 10-30 C	FM 3-9 Liquid	FM 3-9 Vapor
GD	Not Avail	5 - 48
HD	Not Avail	6 - 168
VX	Not Avail	1800 -3600

Model Prediction Improvement By Agent Fate Program



Current State of Agent Fate Data

Less than 400 usable live agent fate experiments exist

- Deficiencies of Existing Data Points:
  - Sparse
  - No coordination between tests
  - Limited test duration
  - No repeatability
  - Missing data
  - Illegible source material
  - Antiquated test equipment
  - Significance versus quantification testing

Circa 1999

Agent	Temp (°C)	Surface: Grass	Sand	Soil	Concrete	Asphalt
A	≤ 0	no data	no data	no data	no data	no data
	≤ 15	no data	no data	no data	no data	no data
	≤ 30	8	9	no data	2	2
	> 30	no data	6	no data	2	2
B	≤ 0	no data	1	no data	1	no data
	≤ 15	no data	no data	no data	no data	no data
	≤ 30	7	10	no data	2	2
	> 30	no data	6	no data	2	2
C	≤ 0	no data	no data	no data	no data	no data
	≤ 15	no data	1	no data	no data	no data
	≤ 30	16	4	38	1	1
	> 30	1	3	no data	no data	no data
D	≤ 0	no data	no data	no data	no data	no data
	≤ 15	no data	no data	no data	no data	no data
	≤ 30	no data	5	no data	no data	no data
	> 30	no data	2	no data	no data	no data
E	≤ 0	no data	3	no data	no data	no data
	≤ 15	no data	1	no data	no data	no data
	≤ 30	4	49	64	5	1
	> 30	1	23	4	no data	no data
F	≤ 0	no data	no data	no data	16	no data
	≤ 15	2	no data	no data	9	1
	≤ 30	9	1	4	57	2
	> 30	no data	no data	no data	4	no data

Agent Fate Program will start to fill the holes in this matrix (Comprehensive, systematic, and integrated program)

Agent Fate Concept And Approach

Three Major Thrusts

Predictive Modeling

Statistical Design of Experiments

- Secondary Evaporation Modeling
- Residual liquid contact & pickup

Lab / Wind Tunnel / Field Trials

- Surface Evaporation
- Substrate Interactions

(vapor flux, temp., wind, RH, agent, substrate, drop size, spread rate, etc.)

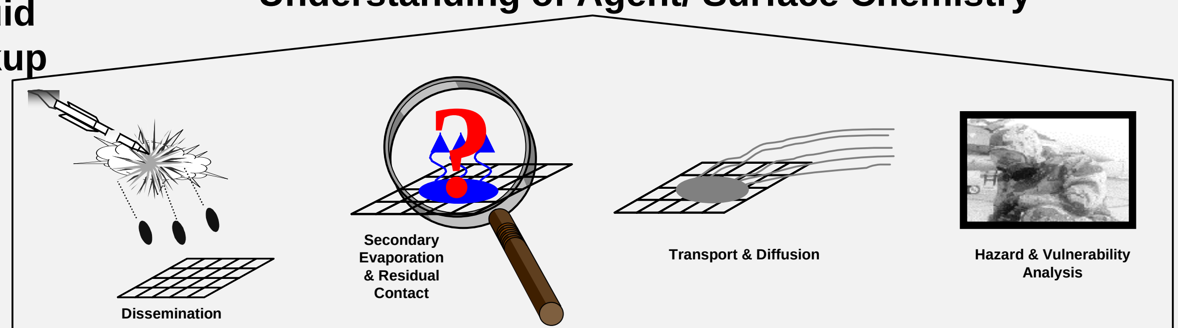
Methodology Development

- NMR
- HS-SPME
- Soil System

Understanding of Agent/ Surface Chemistry

Science Based Predictive Capability for Agent Persistence

- Secondary evap model for JEM
- Interim VLSTRACK
- CHEMRAT/JOEF
- Field Manuals



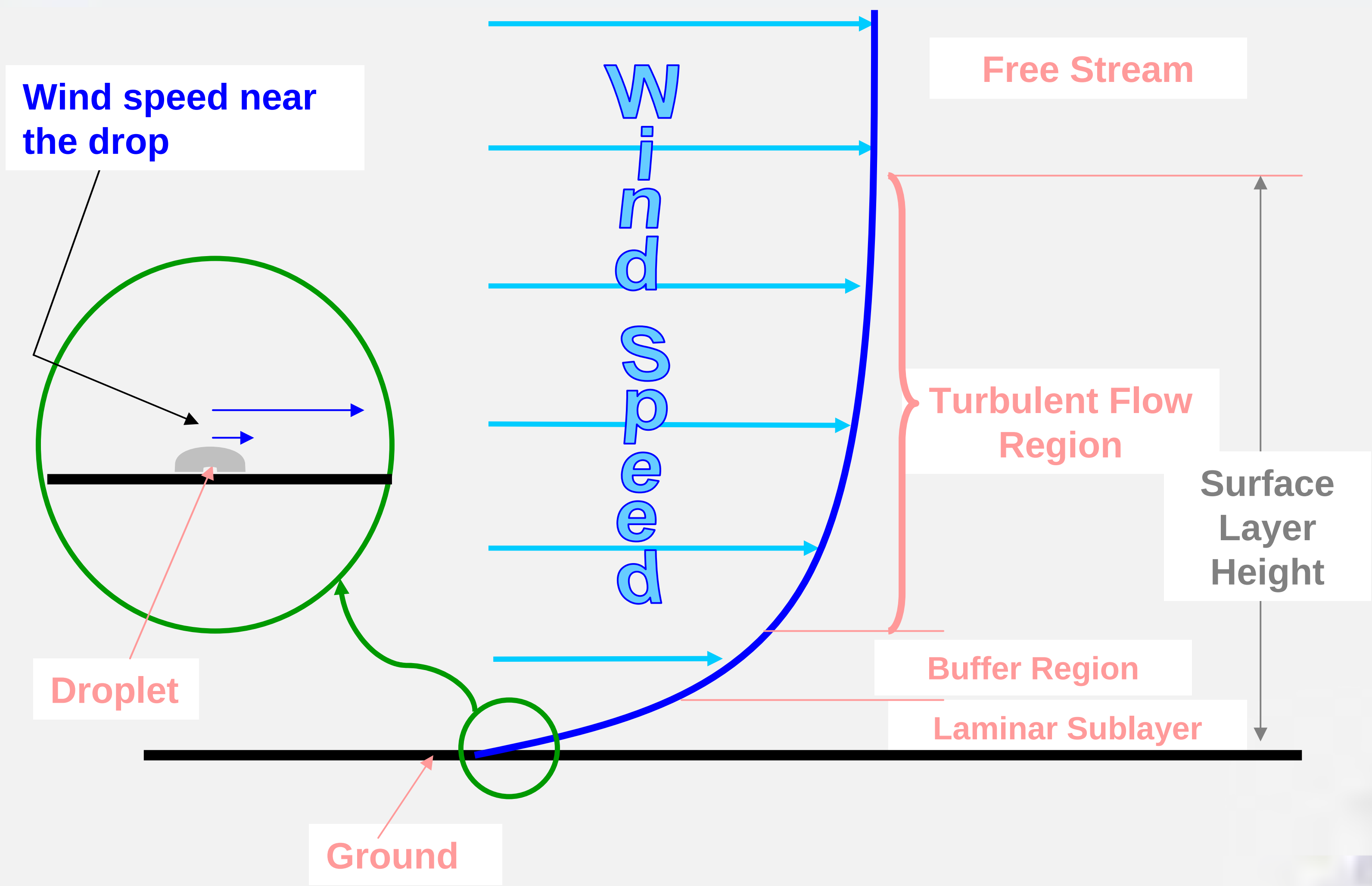
Operational Environment

Testing Matrix

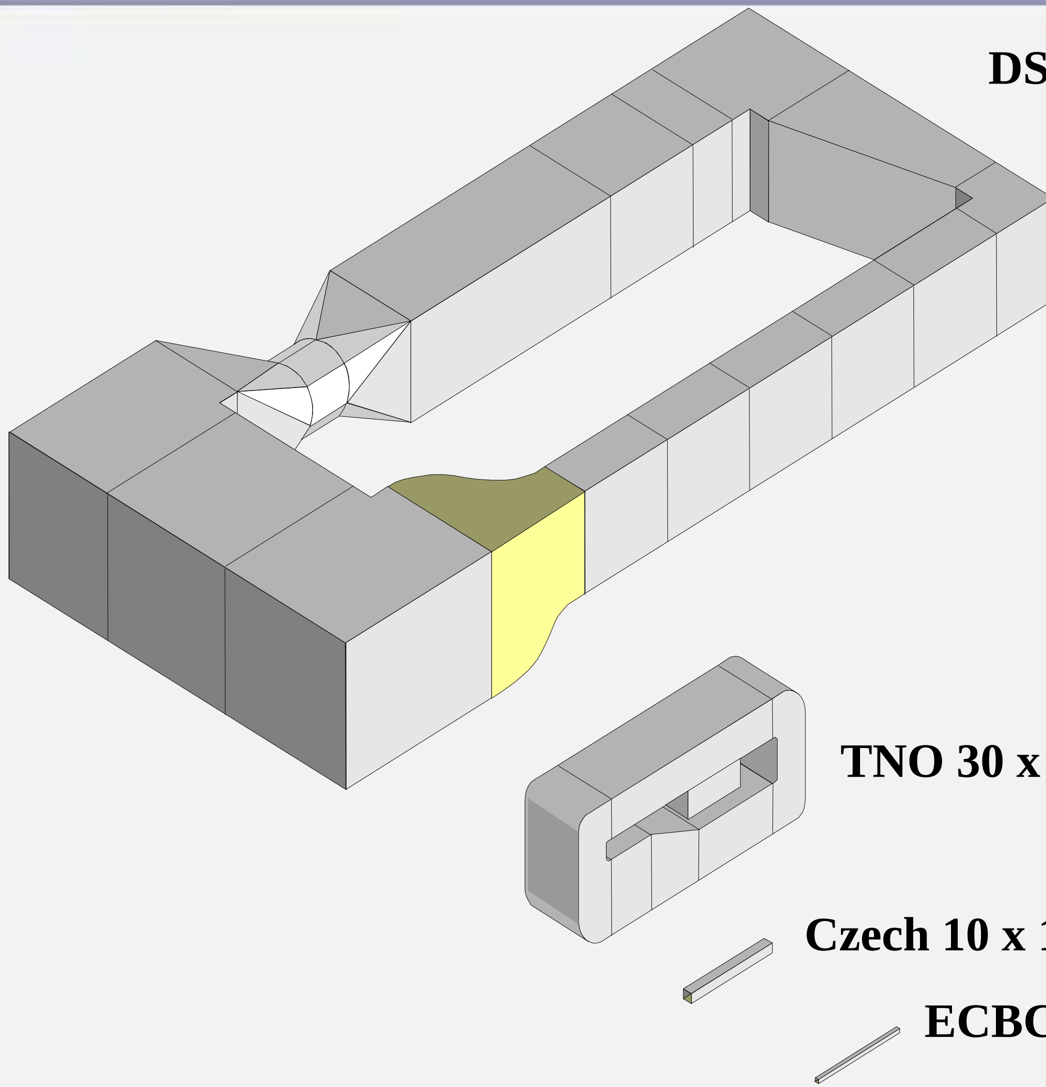
Priorities: 1. non-absorptive, non-reactive
2. absorptive, non-reactive
3. non-absorptive, reactive
4. absorptive, reactive

Agents	**Substrates**	**Test Matrix**
HD	**Glass[1,2]/Teflon[1]**	**Velocity @5mm: 0.2, 1.6, 3.3 m/s**
VX	**Concrete[4]**	**Drop Size: 0.0005, 0.2, 9.0 µL**
GD	**Asphalt[4]**	**Temperature: 0/20, 25, 55 deg. C**
NTA	**Grass[2]**	**RH: 5 to 90%**
Thickened VX	**Sand[2]/Clay[2]**	
Thickened GD		

Atmospheric Surface Layer



Agent Fate Wind Tunnels (to the same scale)



DSTL 50 x 100-cm

TNO 30 x 65-cm

Czech 10 x 10-cm

ECBC 5 x 5-cm

Scale Independence of Agent Fate Wind Tunnels

No scaling corrections are required between the various sizes of wind tunnels used in the Agent Fate Program. Since the **tunnels all possess the same velocity profiles** (based on realistic wind conditions), the **agent/substrate combinations** being tested **experience the same air flow** and evaporation environment.

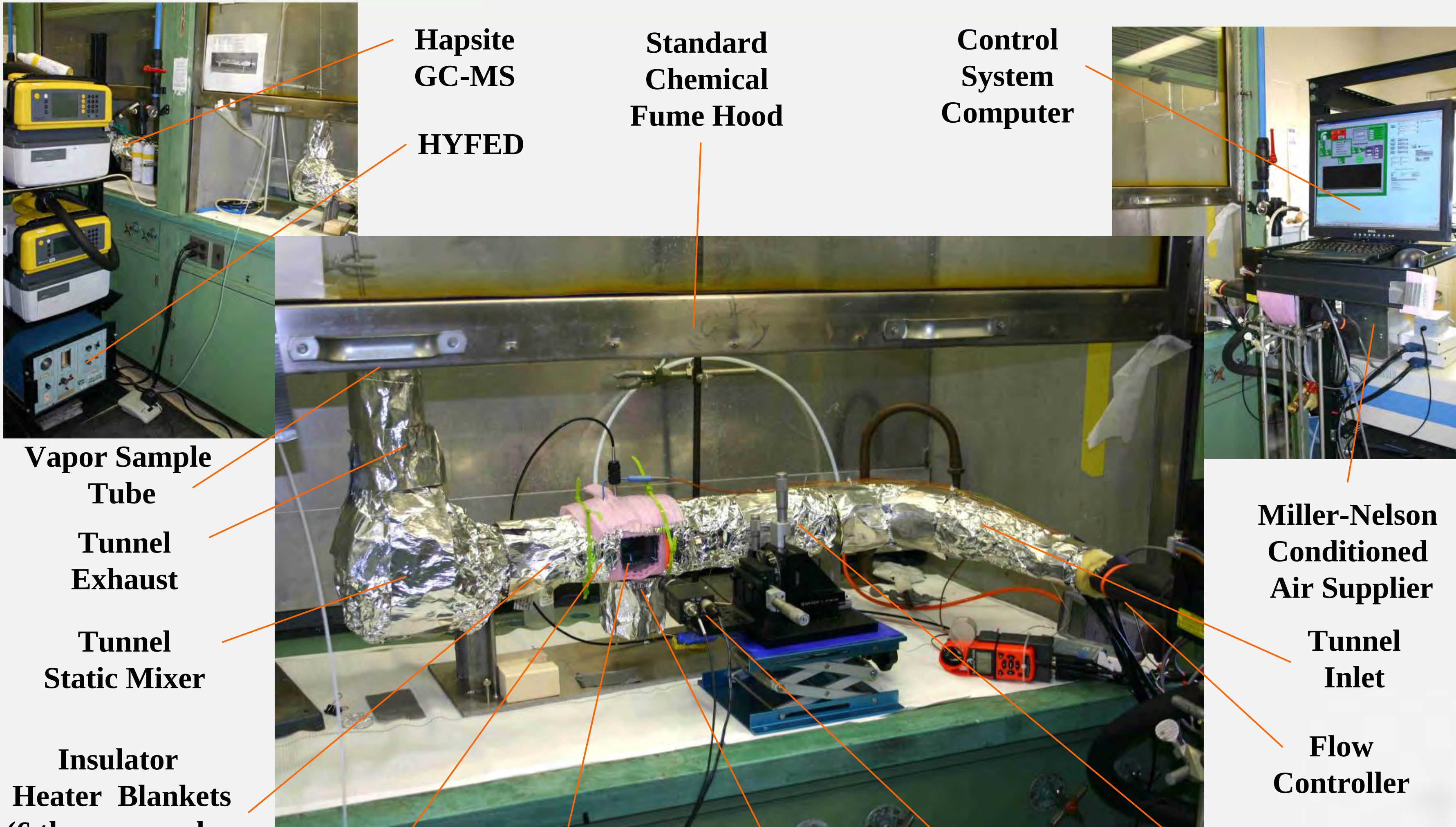
Accordingly, identical data should be obtained for identical agents/substrates tested in any of the tunnels. This finding allows the results from the tunnels to be directly compared and also eliminates the need to perform duplicate tests in the different tunnels.

NO SCALING CORRECTIONS ARE REQUIRED

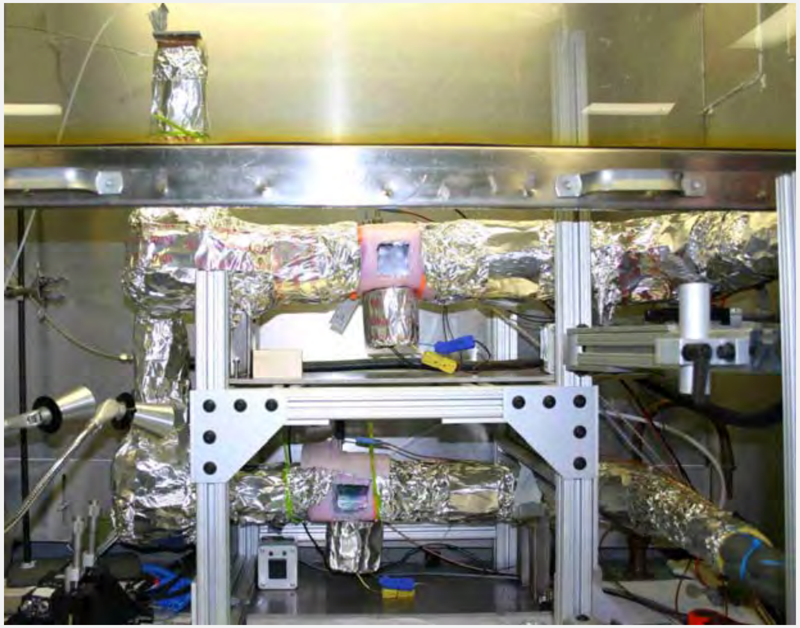
- **Based on assessment by**:
Dr. Klewicki, University of Utah
Recognized expert in theoretical and experimental atmospheric boundary

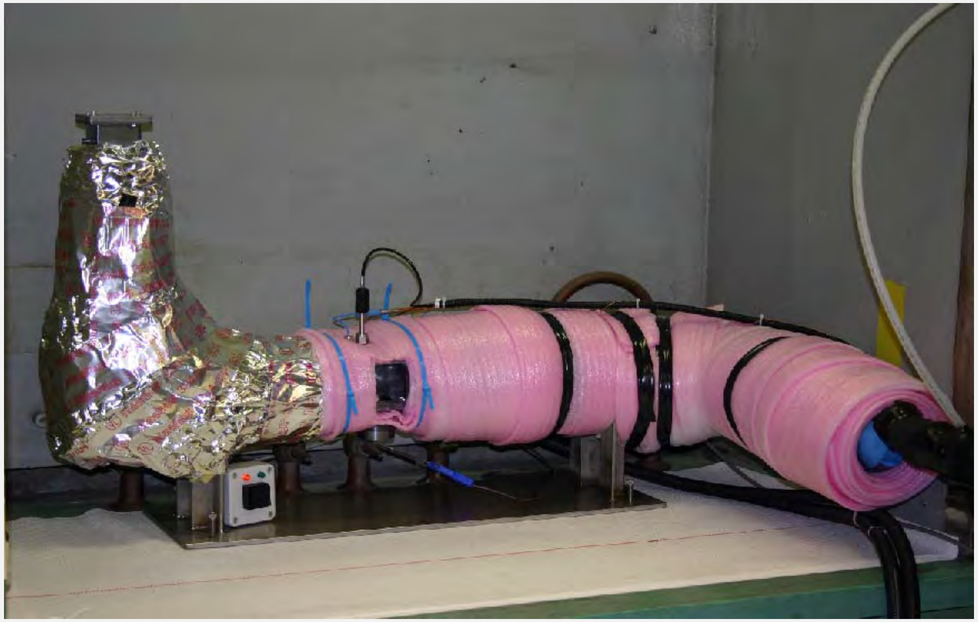
AGENTFATE

5 x 5-cm Wind Tunnel Operational Arrangement



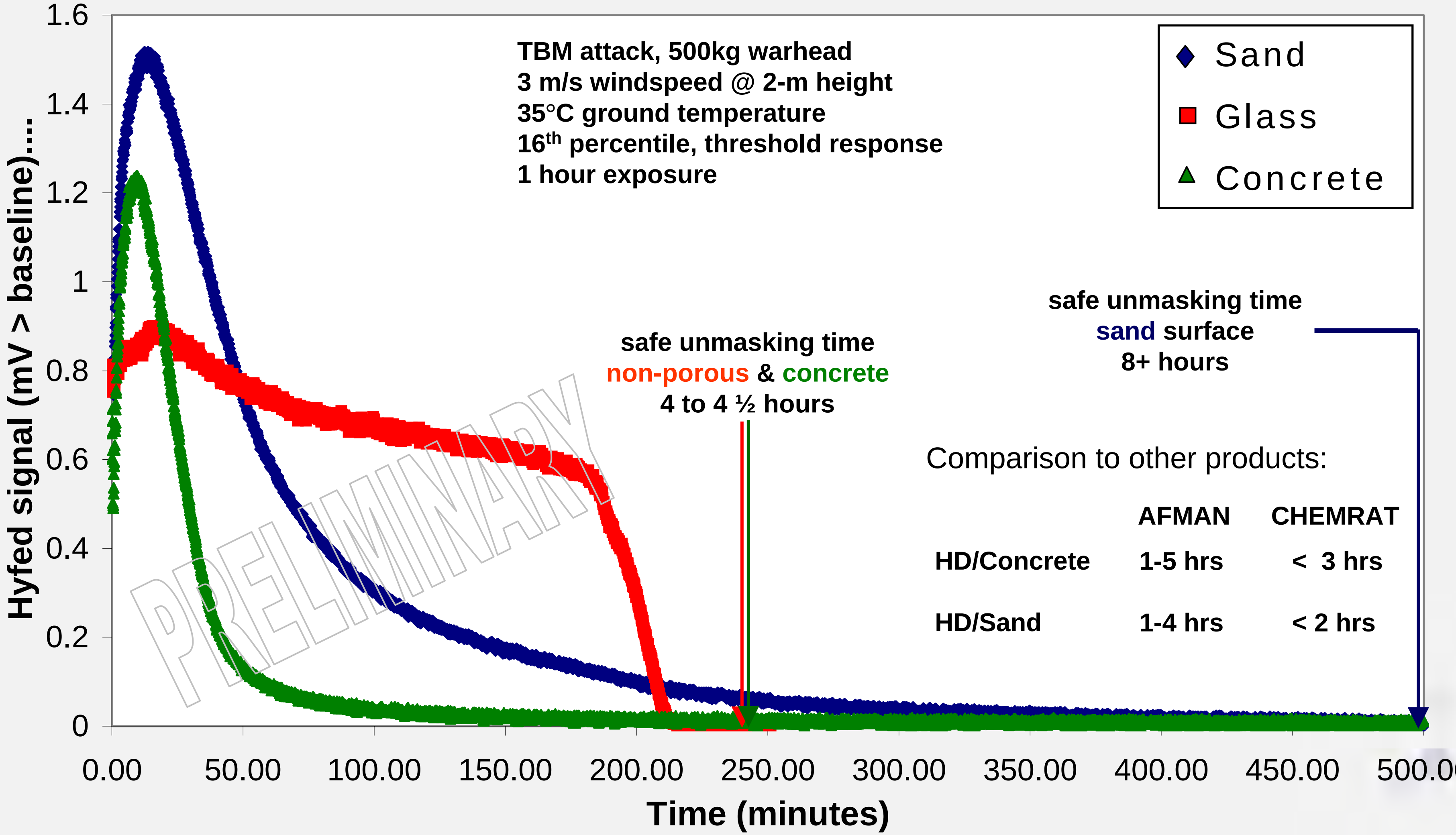
5-cm Wind Tunnels





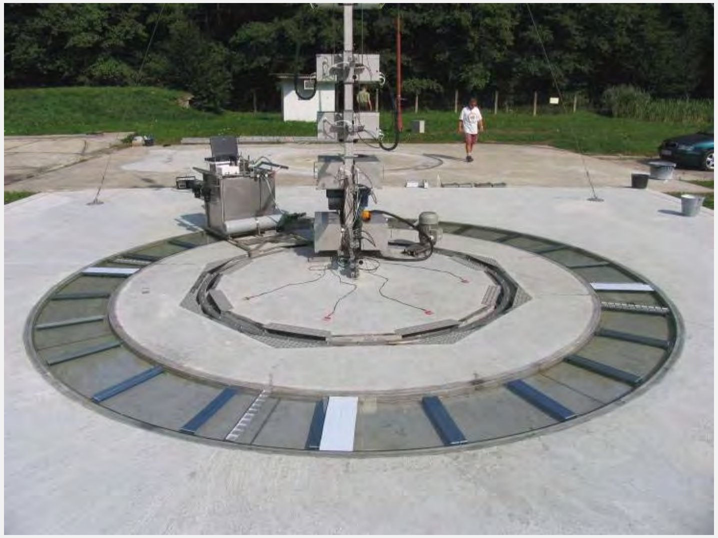
Sub-ambient ECBC windtunnel

Persistence Estimates
HD On Concrete/Sand Vapor Hazard



Open Air Field Trials
Improved Test Pad

- Track-driven system to regulate dissemination device speed
- New concrete pad
- New sampling mast, arms, and sampling hardware/equipment



Open Air Field Trials
Agent Dissemination Device

- 2005 Objectives were to minimize:
  - Variance in circumferental deposition density
  - Variance in annular deposition density (more uniform density)
  - Droplet overlap and droplet size distribution
- Objectives met with new dissemination device (goose)
- New goose performance allows for more accurate
  - Mass balance
  - Determination of evaporation rate

HD On Glass (15 Sep 2005)

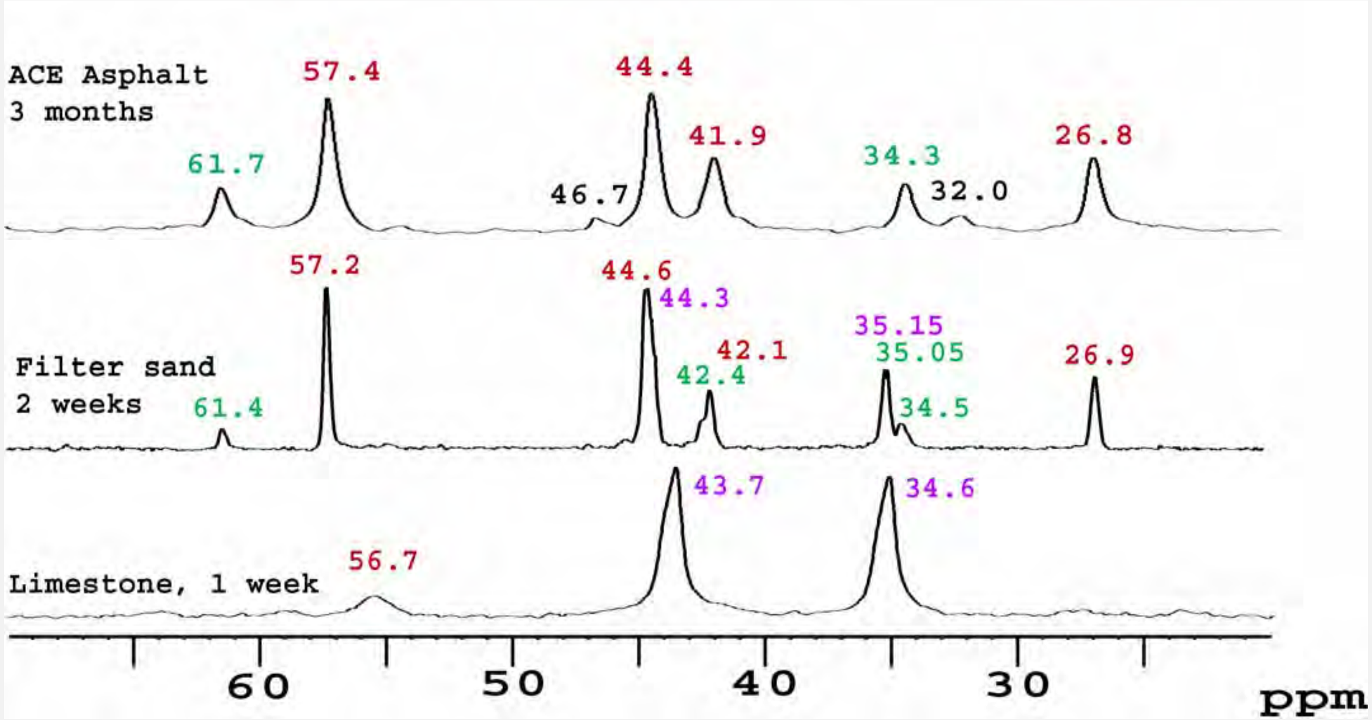
Methodology Development

Results: Degradation of HD* on Ambient Substrates

• Limestone:	No reaction in 7 months
• Asphalt:	No reaction in 2 months
• Sand:	No reaction in 7 months
• Mortars:	Half-lives of weeks to years.
• Concrete:	Half-lives of weeks to years.

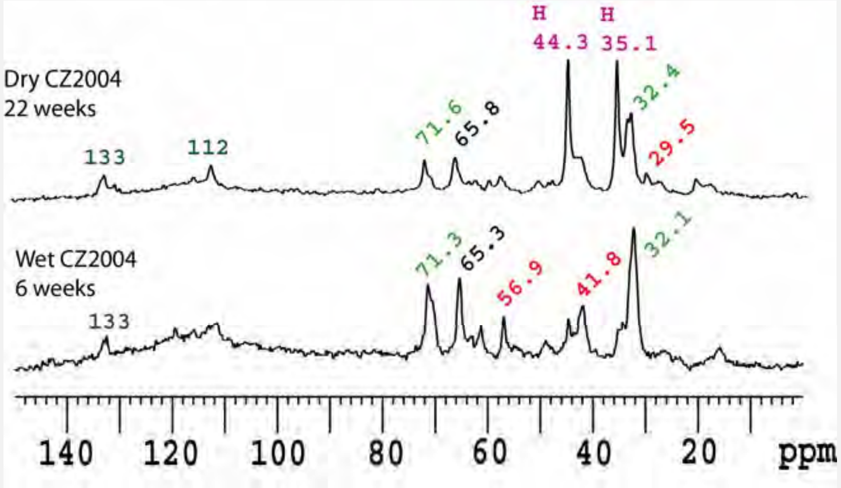
HD* and Water on Asphalt, Sand & Limestone

- The sulfonium ion H-2TG (toxic) was the major product, >75%.
- An alcohol – thiodiglycol (non-toxic) and/or chlorohydrin - was also formed.
- Half-lives: ~1 month for asphalt and limestone, 1-2 weeks for sand.



HD* and Water on Concrete

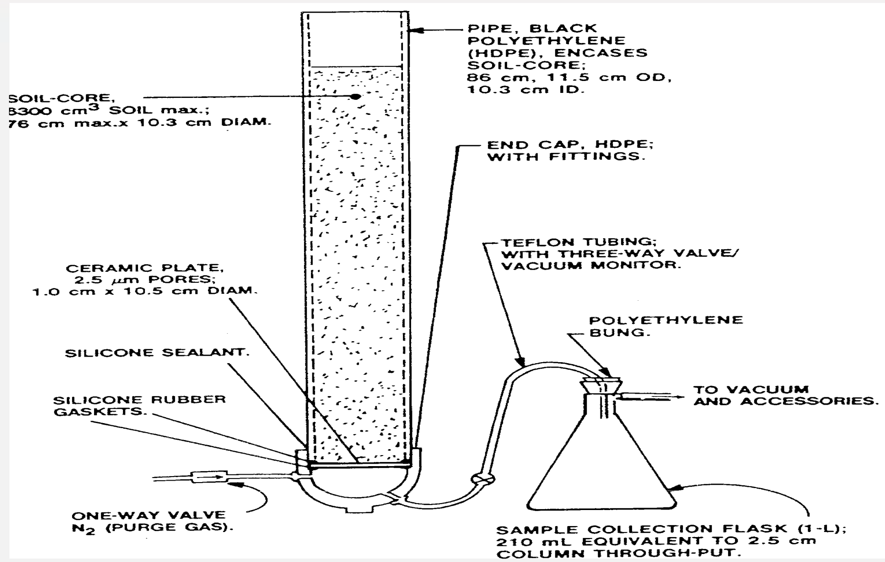
- The product distribution varied from sample to sample.
  - The sulfonium ion H-2TG (toxic) was a minor product, 0-30%.
  - 2-chloroethyl vinyl sulfide, minor product, 10–15%
  - Thiodiglycol (non-toxic) was also formed, 5 – 25%.
  - Product tentatively identified as 1,4-oxathiane, ~30%
  - Unknown at 65.5 ppm, 25-50%
- Half-lives: 3 – 9 days for wet concrete and mortar samples.
- Non-toxic products in green; toxic in red.



Comparison of HD* on ambient concrete ("dry") and with added water ("wet").

The same products were formed; water decreased the half-life from months to days.

Soil System Unit



General Schematic

References

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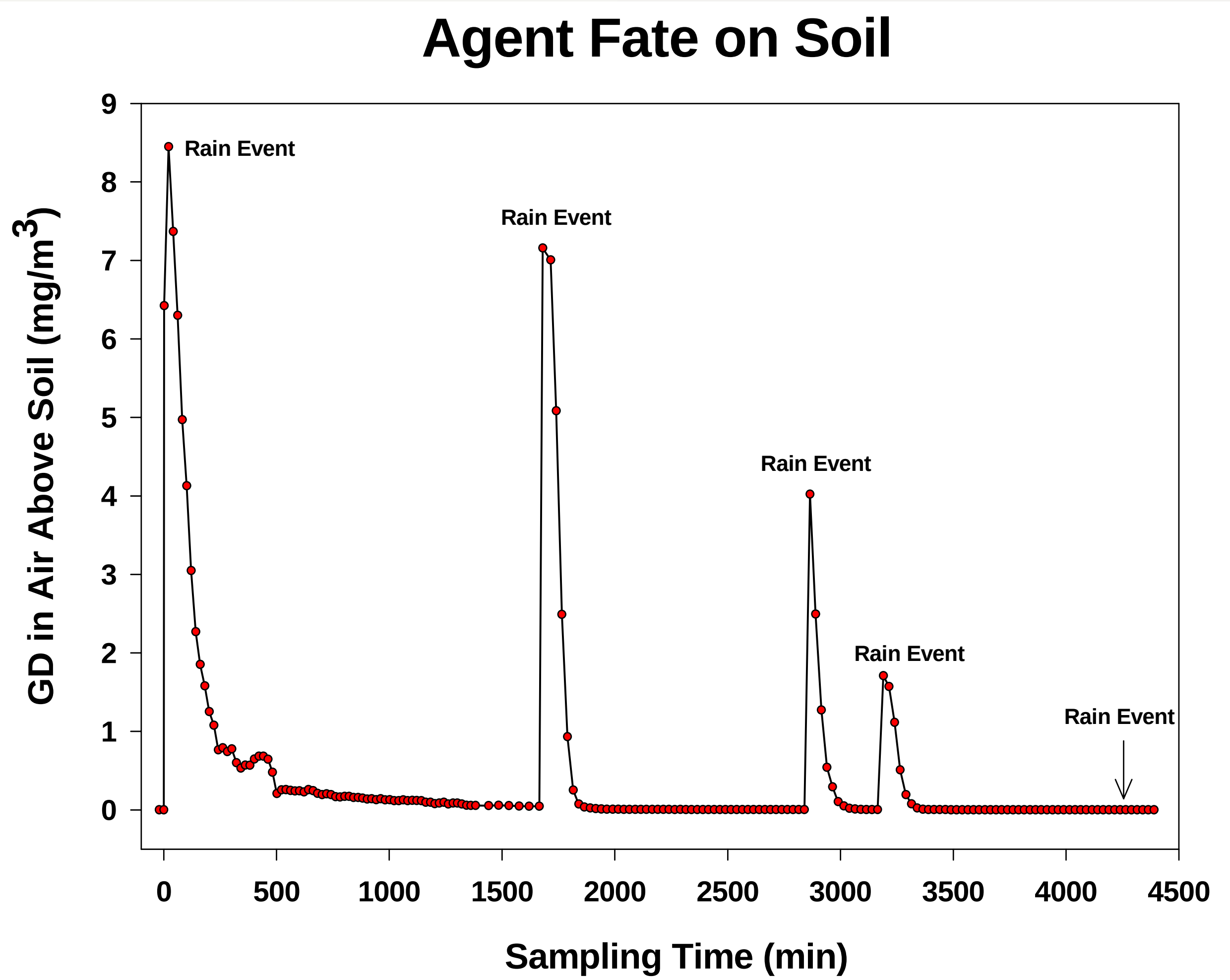
Checkai, R.T., Wentsel, R.S., Phillips, C.T., Yon, R.L. 1993. Controlled Environment Soil-Core Microcosm Unit for Investigating Fate, Migration, and Transformation of Chemicals in Soils. J. Soil Contam. 2(3):229-243.

USEPA. 1996. Ecological Effects Test Guidelines: Terrestrial Soil-Core Microcosm Test. EPA712–C–96–143. Office of Prevention, Pesticides & Toxic Substances, Washington, DC.

Environmental Analysis of Contaminated Sites. 2002. Sunahara, G., Renoux, A., Thellen, C., Gaudet, C., Pilon, A., Eds. John Wiley & Sons, New York, NY.

Checkai, R.T., et al. 2004. Innovative Methods for Investigating the Fate of Chemical Warfare Agents in Soil. 24th Army Science Conference. Accepted for presentation and publication.

Simulated Rain Event On Soil

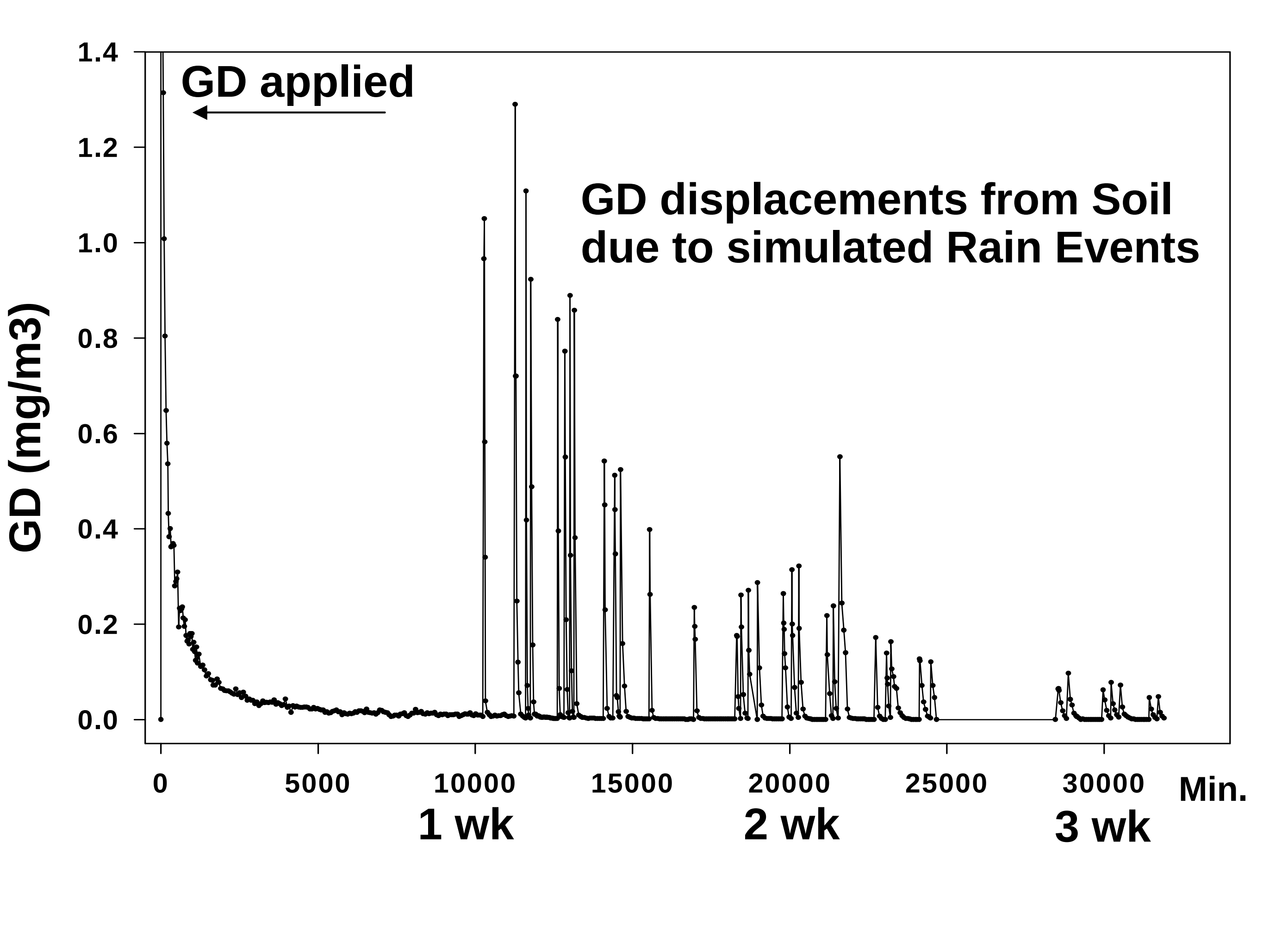


Atmospheric concentrations of GD above the soil surface: Monitored until undetectable (Time 0). Very light simulated rain events sufficient to just moisten the soil surface were applied. Rain events displacement of GD from the soil into the atmosphere above the soil. Successive displacement reactions occurred over the course of days in Response to very light simulated rain events.

Agent Application: 80 µl neat GD dropped onto soil surface using gas tight syringe (applied from 1 inch above soil surface). Approximate droplet size 3.6 µl .

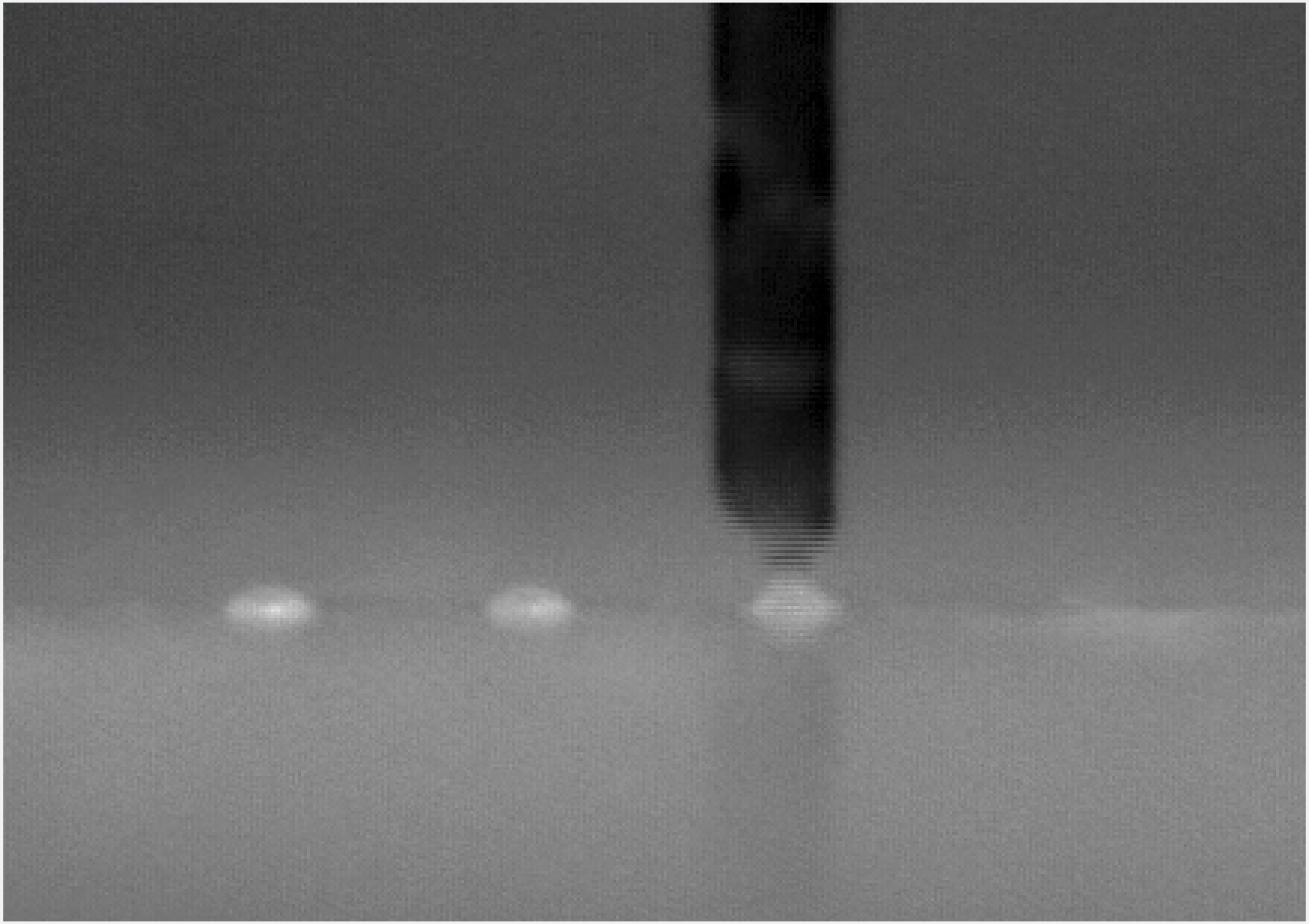
Rain Event: Moisture from the Synthetic Rain Generator, (1.6 ml distilled water/event).

GD on Dry Composite Soil



- GD displacement into air remains $\geq$0.05 mg/m3 (IDLH) after 35 Rain Events
- Light simulated Rain Events were applied after GD conc. in air $\leq$0.005 mg/m3
- GD persists much longer in complex soil (e.g., sand + clay + humus)

1 nL droplets on a Teflon surface



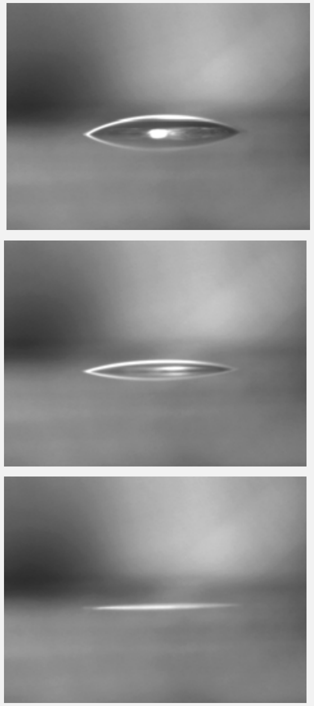
Optical Results

Agent Drop on Non-Absorbent, Non-Reactive Surface

$t = t_0$

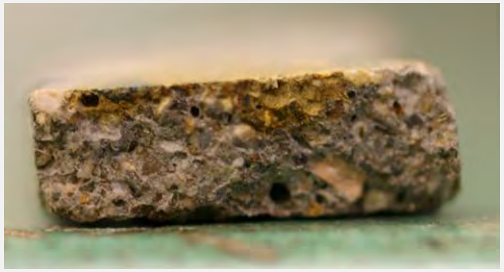
$t > t_0$

$t >> t_0$



Evaporation Sequence

Concrete



Cut-away

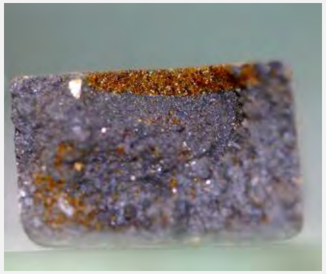
Agent absorbs rapidly

Spreads deep into substrate

Follows aggregate

Varies with concrete type

Asphalt



Cut-away

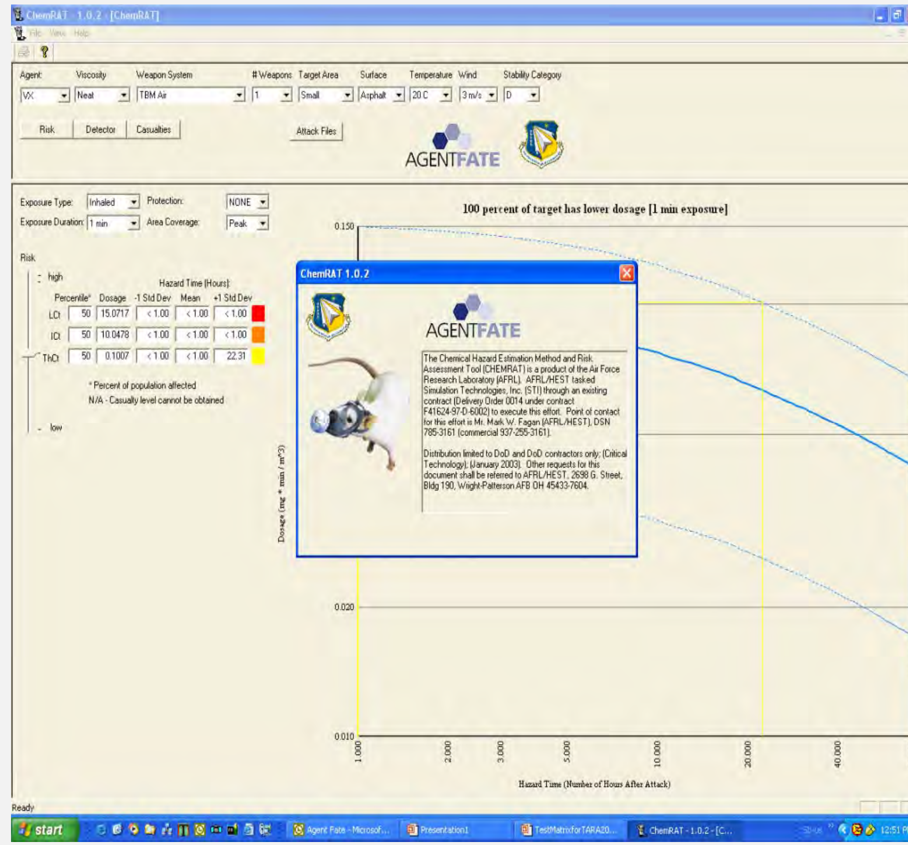
Agent absorbs rapidly

Spreads wide over substrate

Creates tar-like solvate

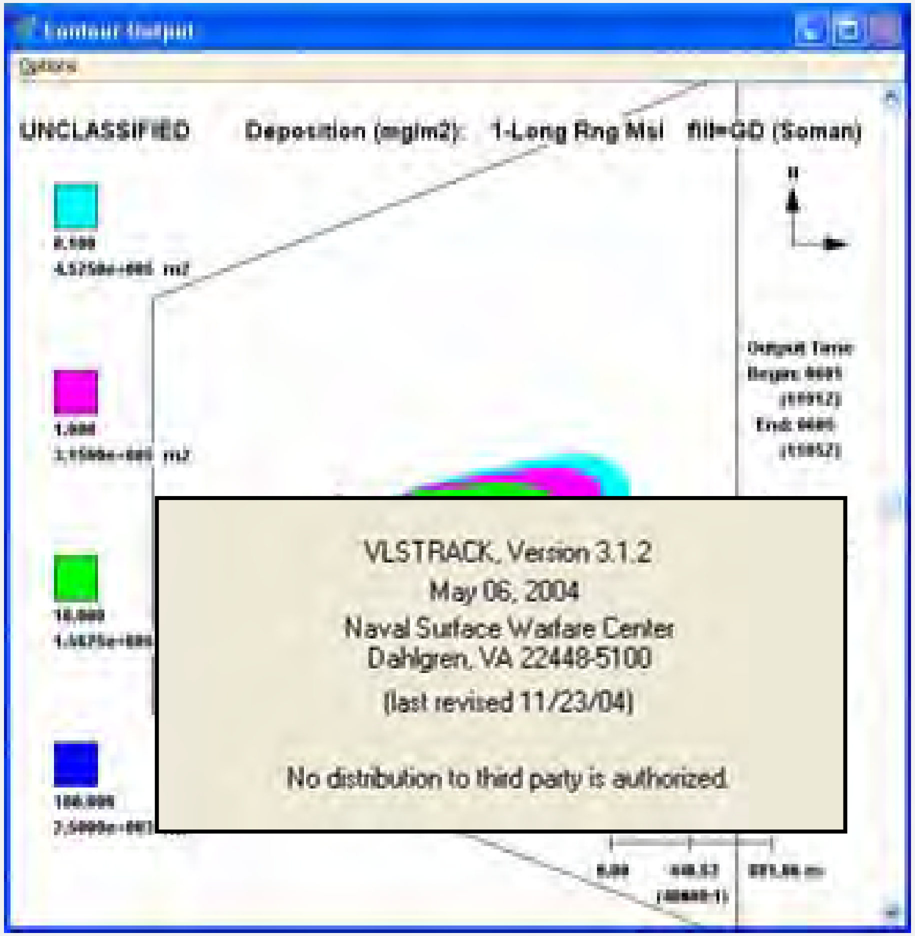
Decision Aiding Analysis & Tools
CHEMRAT

- CHEMRAT initiated by warfighter urgent need request
- Developed and fielded in 3 months
  - Ver 1.0 released in Jan 2003
  - Deployed to OIF
- Interim accredited by DATSD-CBD in April 2003
- Transitioned to JOEF in FY05
- Currently used by USAF, USN, NORTHCOM, DHS, DOE
- Ver 1.5 to be released in 1st quarter FY06
  - Updated data from Agent Fate Program



Decision Aiding Analysis & Tools
VLSTRACK Update

- VLSTRACK updated to version 3.1.2
  - Released June 2004
- Updated with Agent Fate Program data
- VLSTRACK is integration test bed for transition of Agent Fate evaporation models to JEM
- New contact hazard and liquid pickup model being added



Decision Aiding Analysis & Tools
AFMAN 10-2602 Table Updates

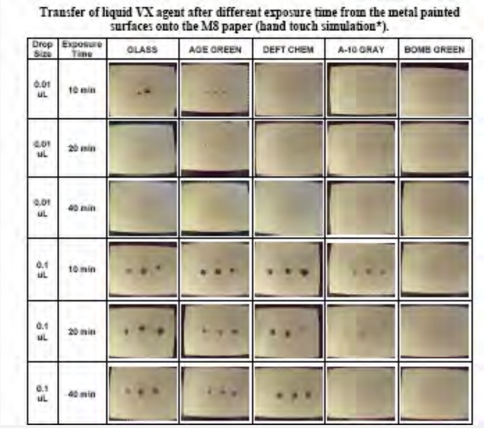
- USAF guidance manuals being updated with revised hazard prediction tables
  - AFMAN 10-2602
  - AFMAN 10-2517
- Estimates derived from updated VLSTRACK predictions
- Incorporates newest agent fate data
- Scheduled release in Dec 2005

Vapor Hazard VX On Concrete ECt 16

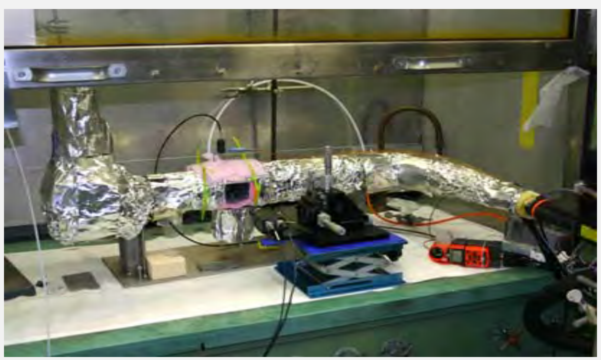
		Stability		PSC D	PSC F	PSC D	PSC F	PSC D	PSC F
		Wind Speed (knots)		2		6		10	
Agent	Release	Munition	Temp °C (°F)						
VX	Low Alt.	TBM	-5 (23)	0.21	0	0.0	0	0.03	0
VX	High Alt.	TBM	-5 (23)	0	0	0.0	0	0	0
VX	Low Alt.	TBM	10 (50)	24.0	16	0.49	0	0.3	0.1
VX	High Alt.	TBM	10 (50)	9	0	0	0	0.1	0.0
VX	Low Alt.	TBM	25 (77)	72	72	3.57	1.5	1.88	0.9
VX	High Alt.	TBM	25 (77)	72	20	4.6	0.43	0.6	0.22
VX	Low Alt.	TBM	50 (122)	72	72	56.19	72	45.19	22.19
VX	High Alt.	TBM	50 (122)	72	72	43.19	16	7.8	13.5

Decision Aiding Analysis
Revised C-CW CONOPS and TTPs

- Leveraged live agent outdoor tests to quantify and assess detection levels of:
  - CAMs
  - M-22 ACADAs
  - M-8 paper
  - M-256A kits
  - HAPSITE
  - M-279 surface sampler
- Determine droplet spread factors
- Quantify transfer of liquid agent by vehicles
- Determine effectiveness of foot/glove decon procedure



Transitioning CW Agent Fate S&T Into Products For CBDP Users



Vapor Hazard VX On Concrete ECt 16									
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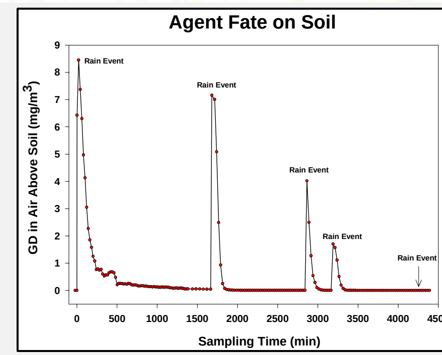

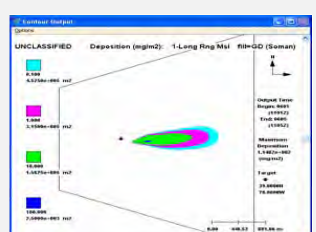

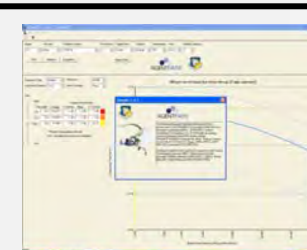

S&T for Chem Bio Information Systems Working Group A-I

Dispersion Modeling & Sensor Data Fusion

10:20-10:50	**Overview of Hazard Prediction Modeling Program**
10:55-11:25	**Source Term Estimation Module (STEM)**
11:30-12:00	**STEM demo : HLA Compliance**
12:00-1:00	**LUNCH (On your own)**

S&T for Chem Bio Information Systems
Session A-II
Operations Effects Modeling

10:20-10:50	**Droplet Reaction and Evaporation of Agents Model**
10:55-11:25	**Chemical Agent Fate Program (CAFP) Development of an Evaporation Model for HD on Non-Porous Surfaces**
11:30-12:00	**Applying Quantum Chemical Theory to Fate of Chemical Warfare Agents**
12:00-1:00	**LUNCH (On your own)**

S&T for Chem Bio Information Systems
Session A-III

Battlespace Management

10:20-10:50	**Shared COP**
10:55-11:25	**Next Generation CB Battle Management System**
11:30-12:00	**Next Generation CB Battle Management System**
12:00-1:00	**LUNCH (ON YOUR OWN)**

S&T for Chem Bio Information Systems
Session A-IV
Decision Making and Support

10:20-10:50 **Decision Support Analytical Framework**

10:55-11:25 **Virtual Prototyping Feasibility/Benefit and CB Common Knowledge Base**

11:30-12:00 **Multivariate Decision Support Tool**

12:00-1:00 **LUNCH (ON YOUR OWN)**

S&T for Chem Bio Information Systems Session A-V

Special Topics: Test and Evaluation

10:20-10:50	A Quantitative Tool for the Identification, Correlation, and Selection of Chemical Agent Simulants for OT&E; Implications for and Applications to Current and Future Programs
10:55-11:25	MNS/CBRN System Integration
11:30-12:00	Optimizing Sensor Placement for CB Defense
12:00-1:00	LUNCH (On your own)

S&T for Chem Bio Information Systems
Working Group B-I
Dispersion Modeling & Sensor Data Fusion

1:00-1:30	**Fusion of CB Data and Model Output**
1:30-2:00	**Chemical/Biological Source Characterization**
2:00-2:30	**Optimizing Sensor Placement for CB Defense**
2:30-3:00	**Sensor Location Optimization Tool Set**
3:00-3:30	**Overview of Mesoscale Meteorological Modeling for Dispersion Applications at the Naval Research Laboratory**
3:30	**Working Group I Adjourns for the Day**

S&T for Chem Bio Information Systems
Session B-II
Operations Effects Modeling

1:00-1:30	**The Need for CBRN and Medical COI Interoperability and the Proposed Way Forward**
1:30-2:00	**Providing Capabilities-Based Analysis in Dynamic Operational Environments: Leveraging Integrated Architecture and Use Cases to Define and Deliver Rapid Capabilities**
2:00-2:30	**Advances in Biotechnology and the Biosciences for Warfighter Performance and Protection**
2:30-3:00	**Contamination Avoidance at Seaports of Debarkation (CASPOD) ACTD: A Study in the Importance of Early User Involvement During User Interface and System Capabilities Development**
3:00-3:30	**Development of a Model for Predicting the Aerosolization of Agents in a Stack**
3:30	**Working Group II Adjourns for the Day**

S&T for Chem Bio Information Systems Session B-III

Battlespace Management

1:00-1:30	**A Bayesian Approach for Assessing Confidence in Biological Warfare (BW) Detection Event**
1:30-2:00	**A New BIO IMS for Simultaneous Detection of CWA Material**
2:00-2:30	**Chem-Bio Protection Without Chem-Bio Sensors: Low Cost, Dual Use Alternative Sensor And Information Architectures**
2:30-3:00	**TBD**
3:00	**Working Group III Adjourns for the Day**

S&T for Chem Bio Information Systems
Session B-IV
Decision Making and Support

1:00-1:30	**The Chemical and Biological Defense Information Analysis Center (CBIAC), a Knowledge Management Source for Authoritative Information**
1:30-2:00	**A Chem-Bio Information System for Rapid Knowledge Acquisition to Support Bio-weapons Countermeasures**
2:00-2:30	**Flatland Virtual Data Decision Support Tool**
2:30-3:00	**Coordinating CB engagement scenarios with the CBRN**
3:00-3:30	**BREAK *& Joint Project Manager Information Systems Demo***
3:30-4:00	**Data Model Machine Intelligence in Decision-making (MInD) Automated Generation of CB Attack Engagement Scenario Variants**
4:00-4:30	**Methods for Understanding Human Interface Requirements for Decision Support Tools**
4:30-5:00	**Allocations of Resources in CB Defense: Optimization and Ranking**
5:00	**Working Group IV Adjourns for the Day**

S&T for Chem Bio Information Systems
Session B-V

Special Topics: Test and Evaluation

1:00-1:30	A Distributed Processing Sensor Network for Detect-to-Warn Capability
1:30-2:00	Development of Plague Outbreak Decision Tool
2:00-2:30	Reliable Discrimination of High Explosive and Chemical/Biological Artillery Using Acoustic Sensors
2:30-3:00	Dynamic Multi Sensor Management System
3:00-3:30	Break
3:30-4:00	Infrared Scene Simulation for Chemical Standoff Detection System Evaluation
4:00-4:30	Neutro Test – A Neutron Based Non-Destructive Device for Finding Hidden Explosives
4:30-5:00	A Bayesian Approach for Assessing Confidence in a Biological Warfare (BW) Detection Event
5:00 PM	Working Group V Adjourns for the Day

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Sensor Location & Optimization Tool Set

Chemical Biological Information Systems Conference
Albuquerque, NM

October 2005

Michael J. Smith
ITT Industries
Advanced Engineering & Sciences

Outline

- Sensor Placement
- Modeling & Simulation
- Optimization
- Years One Demonstration
- Summary

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Sensor Placement

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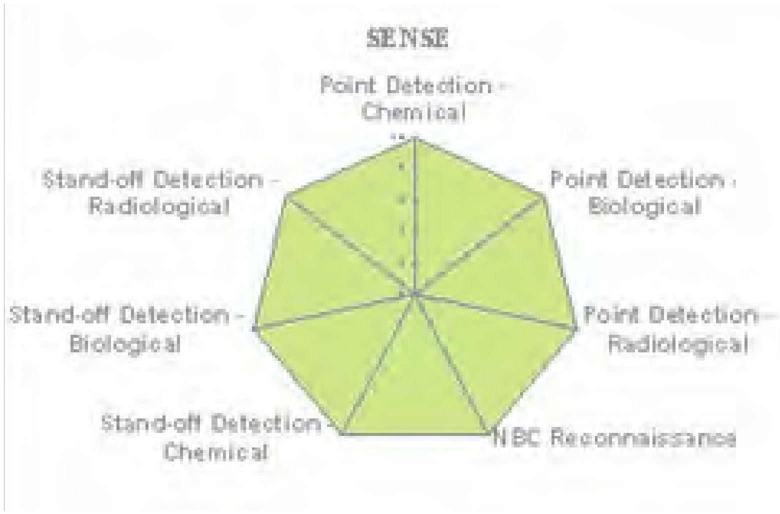
- **SENSE –** The capability to continually provide the information about the CBRN situation at a time and place by detecting, identifying, and quantifying CBRN hazards in air, water, on land, on personnel, equipment or facilities. This capability includes detecting, identifying, and quantifying those CBRN hazards in all physical states (solid, liquid, gas).



Where is the optimal location for sensors in support of the mission?

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SLOTS Program Definition:

Automate **the analytical process and** ***optimize*** **the location of sensors to detect, identify, and quantify the CBRN hazard in support of the commander's intent.**

Determine Threat and Met Range → Create Hazard Cube → Determine Constraints on Sensor Placement → Establish Optimization Criteria → Establish Optimization Range → Optimize

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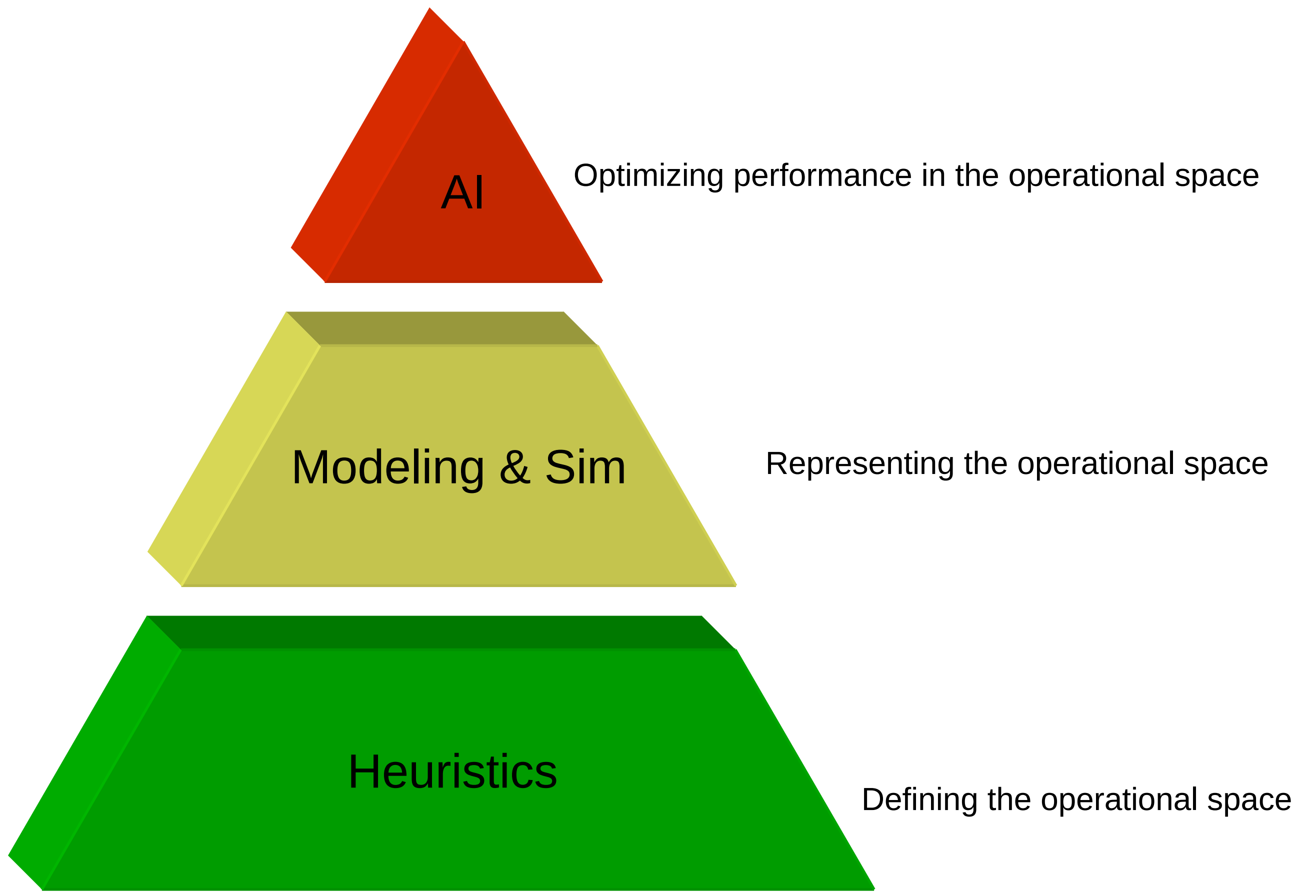
SLOTS Approach:

1. To establish a set of rules governing the emplacement of sensors.

2. Utilize information technologies to automate the sensor placement decision process.

3. Leverage artificial intelligence to optimize the ultimate sensor configuration.



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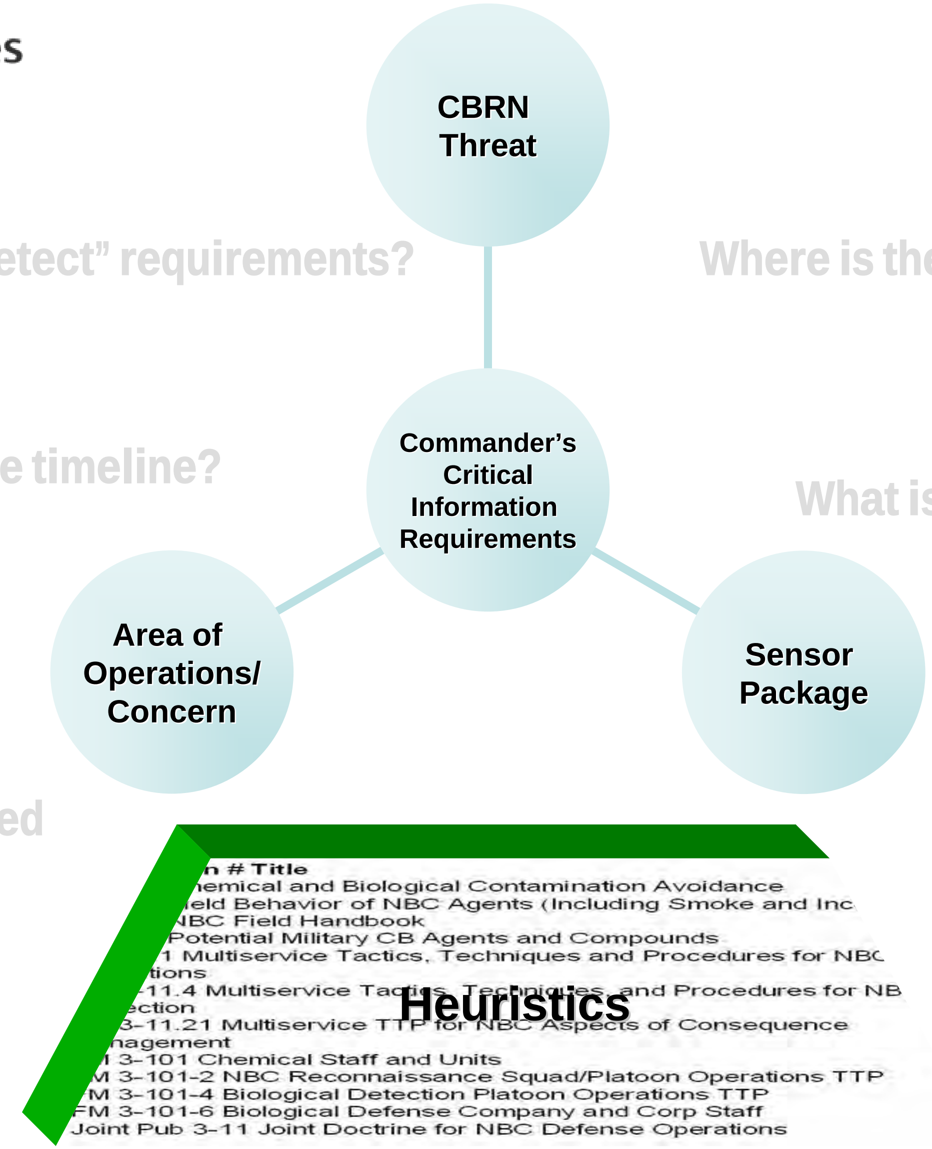
What are the "to detect" requirements?

Where is the operating space?

What is the timeline?

What is the range of threats?



What are the sensors?

What is the supported mission?

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Multi-faceted Dependencies Increase Complexity

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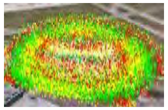


CBRN Threat

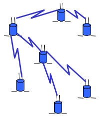
Type A (case 1 & 2) — Type B (Cases 1-6)

Area of Responsibility

Fixed — Expeditionary — Mobile

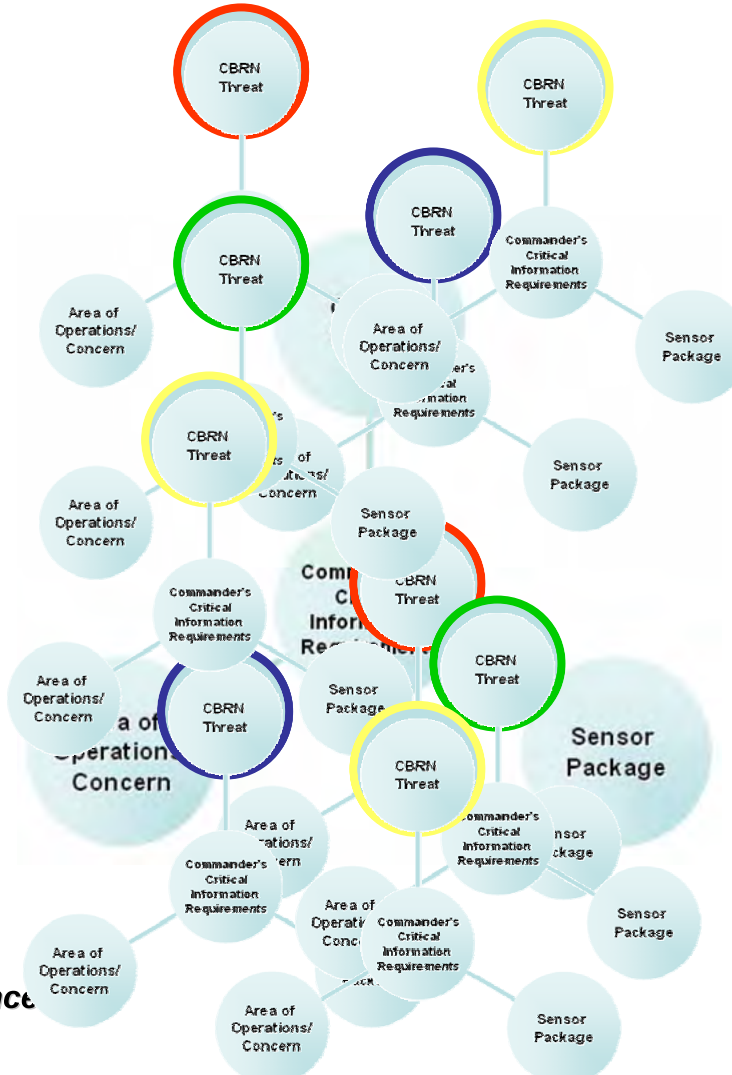
CCIRs

Detect to Warn — Detect to treat



Sensor Network

Point — Standoff



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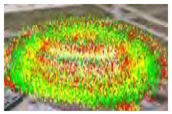
Defining CBRN Threat



Type A (case 1 & 2) **Type B (Cases 1-6)**

Define the CBRN threat – "*Template potential chemical targets or areas of contamination.*" – The enemy order of battle to include agents, weapon systems (warheads and delivery mechanisms), and concepts of employment in the offensive and defensive. Underlying this assessment is an understanding of the field behavior of CBRN agents. This process must reflect time periods of interest, enemy courses of action and named areas of interest.

- ❑Detailed information on enemy CBRN agents capabilities based on the type of units and weapons the enemy has available in the area of operations/area of influence (AO/AI) during a selected time period.
- ❑Detailed information on CBRN weapon systems
- ❑How the enemy would employ chemical, biological, flame, or smoke to support his battle plan.
- ❑Understanding of fill rates associated with the weapons and agents
- ❑Areas of likely employment based on threat employment doctrine.
- ❑Detailed analysis of terrain and weather in the unit's AO during each period of interest and how they could impact on CB, flame, and smoke warfare.
- ❑MOPP guidance for each period of interest (such as, minimum MOPP, automatic masking).

Area of Responsibility

Fixed — Expeditionary — Maneuver

<u>Define the named area of responsibility/influence</u> – "*Designate templated areas that affect the scheme of maneuver as named areas of interest*." – After threat source, terrain and weather most directly impact the extent and duration of the hazard. Detailed analysis of named areas of interest and target areas of interest during periods of concern will shed light on the impact of a CBRN release. Information regarding the NAI, TAI, periods of interest is derivative of the overall battlefield assessment process.

- ❑What is the appropriate operational focus for SLOTS?
- ❑What are the size, typical terrain features, and layout of the selected area?
- ❑What are the most probable threats based on the adversary capability and doctrine? What are the name areas of interest, the target areas of interest in the AOR?
- ❑What is the Force Protection Level Assets?
- ❑What is the impact of the threat on the NAI and FPLs to the commanders scheme of maneuver?
- ❑What is the composition of the units conducting the operational mission and their MTOE?
- ❑Who is the user of SLOTS in these units?
- ❑What is the planning time frame?
- ❑What is the availability of terrain and weather data for the AOR in the given planning time frame?

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Commander's Critical Information Requirements

Detect to Warn — Detect to treat

"*A [CBRN] vulnerability assessment … is the primary means through which the chemical staff advisor participates in the battlefield assessment process*." – The battlefield assessment process is designed to satisfy the commander's intent and reflect the designation of main effort. Information regarding NAIs and TAIs and their constituent critical elements such as C2 facilities, mobility corridors, troop concentrations, and assemble areas will suggest the detection objectives of the sensor arrays. Different detector types and configuration support various detection missions from detect to warn to detect to treat and will be dependent on the METT-TC.

- ❑What are the NAIs and TAIs associated with a mission?
- ❑What is the time period of interest?
- ❑What are the avoidance/protection/recovery objectives for NAI/TAIs?
- ❑What metric supports detect to warning?
- ❑What metric supports detect for treatment?
- ❑What metric supports detect for surface contamination?
- ❑What metric supports detect for unmasking?

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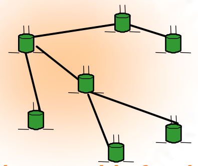
SLOTS



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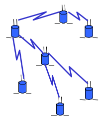
Sensor Network



Point — Standoff

A number of sensor technologies are employed to detect CBRN threats. Sensor technology is specific to a class of agent(s) (nerve, blood, blister, chocking, TIM), its physical properties (solid, gas, liquid) and its size or concentration. These technologies can be grouped into five major categories: **point, stand-off**, analytical, sorbent, and colormetric detectors.

- ❑Chemical / Biological Agents Detected
- ❑TIMs Detected
- ❑Sensitivity
- ❑Resistance to Interferents
- ❑Response Time
- ❑Start-Up Time
- ❑Detection States
- ❑Alarm Capability
- ❑Portability
- ❑Battery Needs
- ❑Power Capabilities
- ❑Environment
- ❑Durability
- ❑Unit Cost
- ❑Operator Skills
- ❑Training

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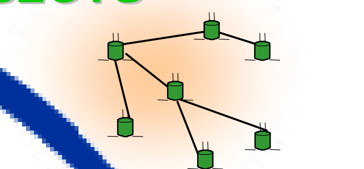
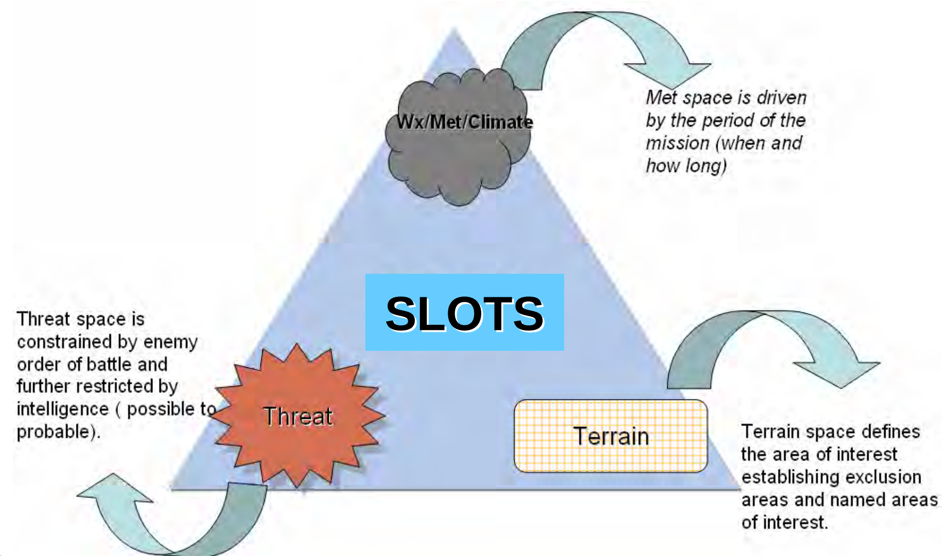
Sensor Placement Dependencies



Mission

Mission defines plans that must be developed and constrains all of the other factors



Mission = Objective (survey, monitor, recon)
Enemy = CB threat
Time = Timelines & met conditions
Terrain = Area of operations
Troops = MTOE
C = Civilians

MTOE

MTOE defines sensor type, numbers, and performance.

Chemical Biological Radiological and Nuclear Vulnerability Assessment Process

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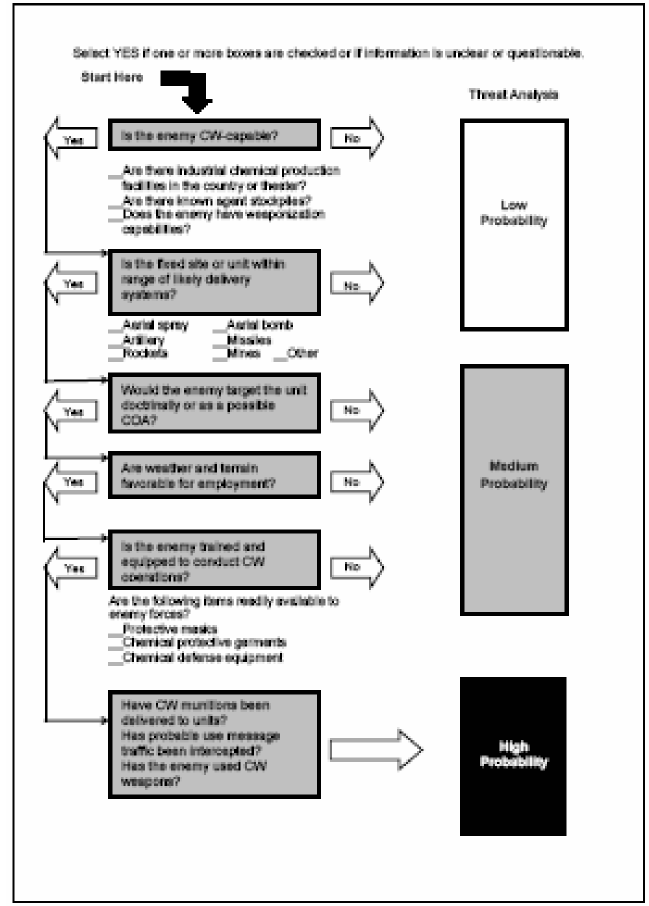
1. Define the Battlespace Environment.
   - Where might the enemy use NBC weapons?
   - What are capabilities/limitations NBC weapons?
   - Where are the densely populated areas?
   - Does area have TIM storage/production/capabilities?
   - What Intel/surveillance/recon (ISR) is available?
   - ID Limits of Command AO and Battlespace.
   - Establish Area of Interest (AOI) Limits.

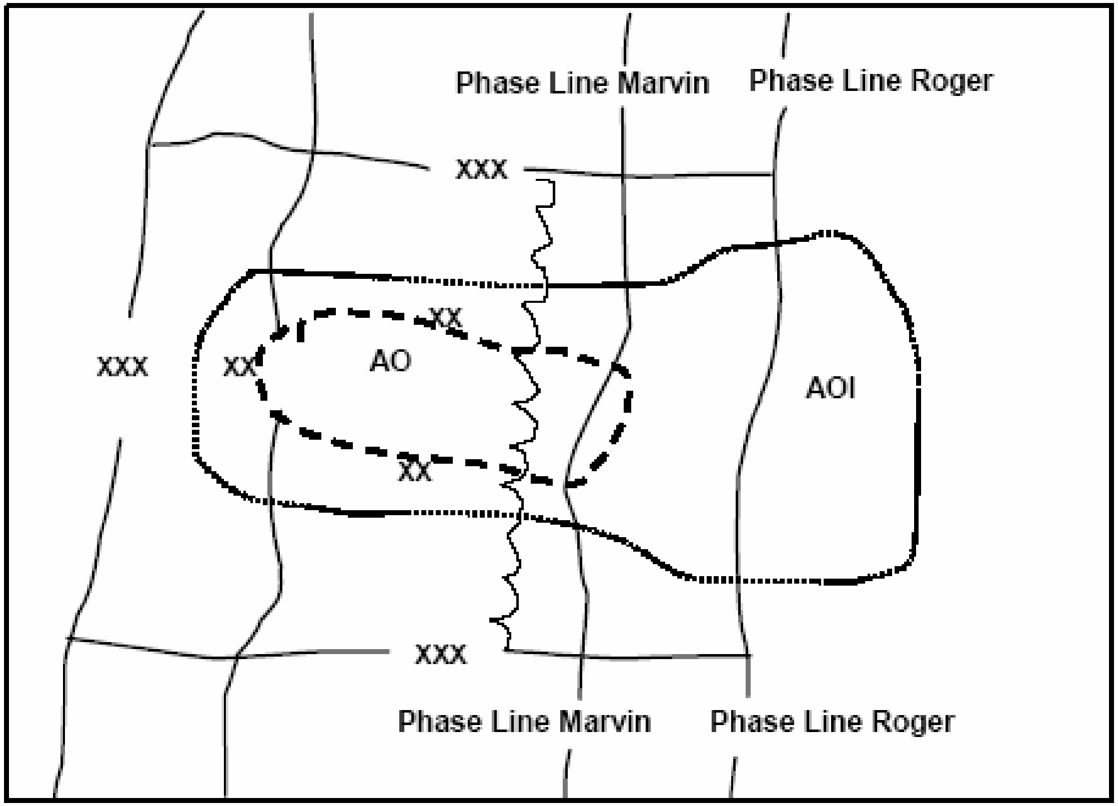
2. The Describe the Battlespace Effects.

3. Evaluate the Threat.

4. Determine the Threat COAs.



Battlespace



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IPB Results

SLOTS

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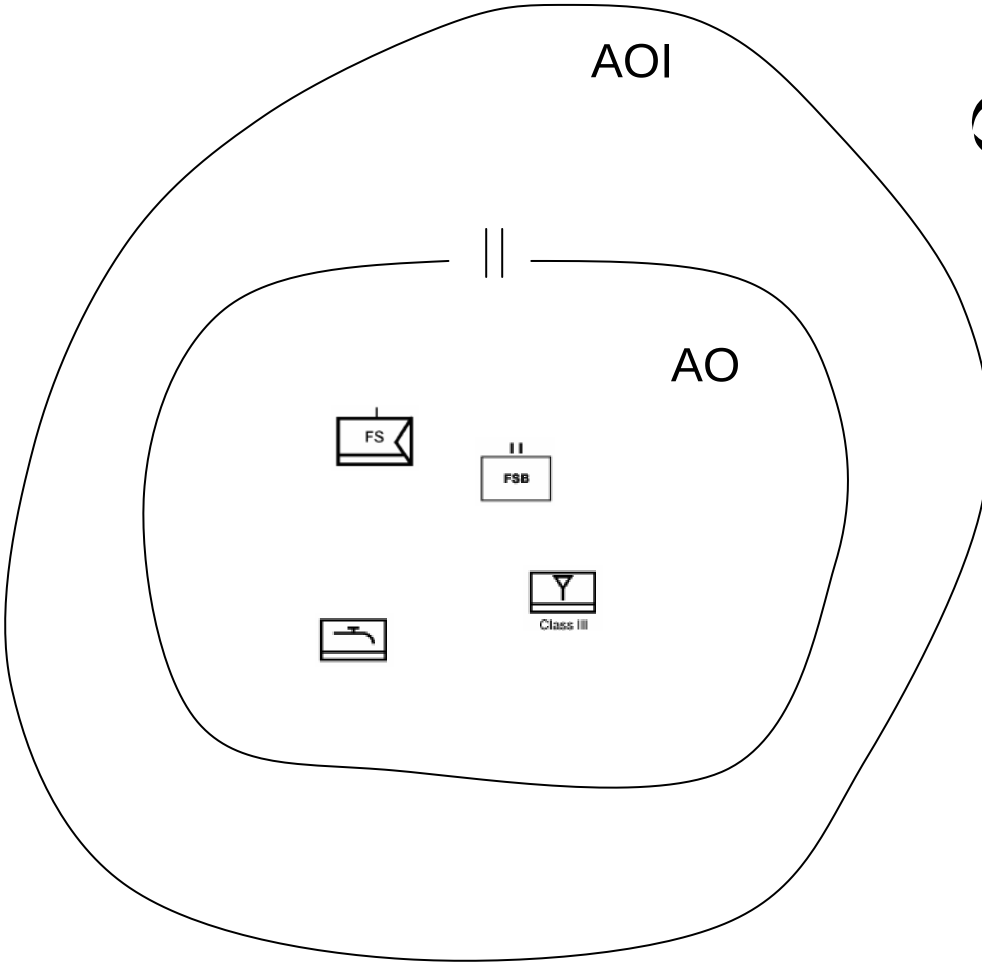
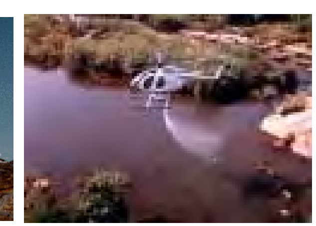
Define the Battlespace Environment.

The Describe the Battlespace Effects.

Evaluate the Threat.

Determine the Threat COAs.





COA 1	COA 2
NAI	NAI
CCIR	CCIR

SLOTS

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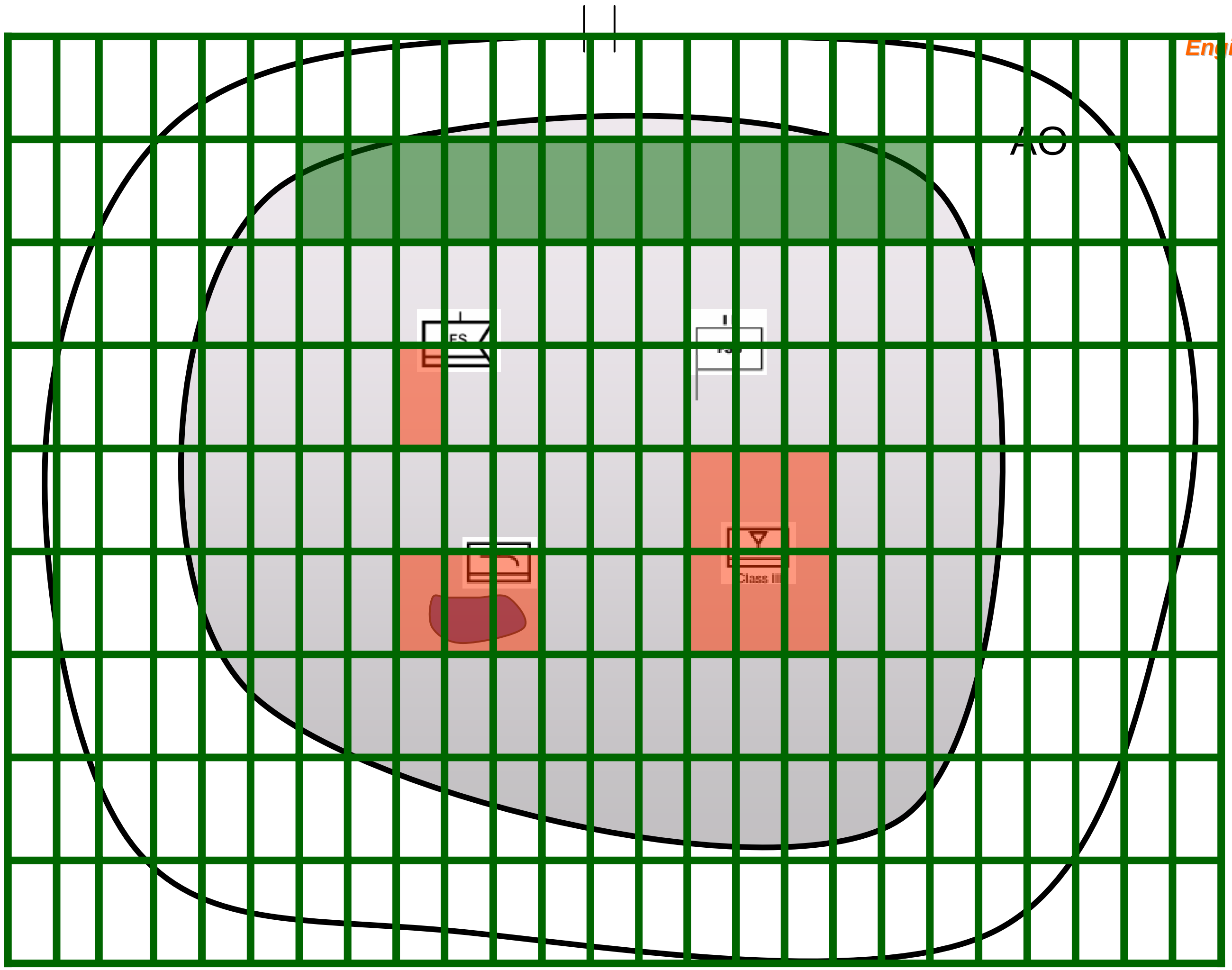
Sensor Placement: Yes/No/Maybe



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Sensor Placement: Yes/No/Maybe

SLOTS

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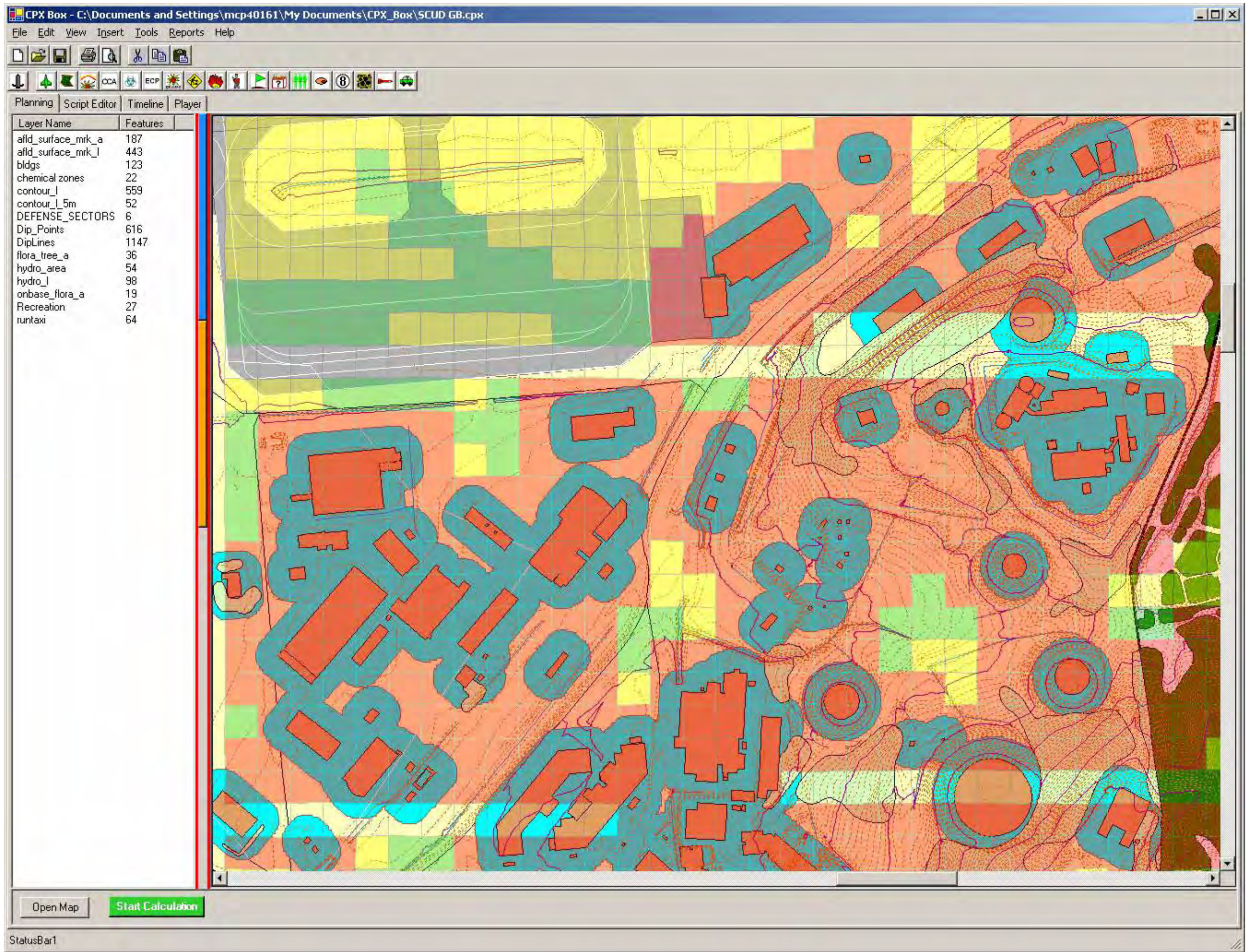

Site Selection

Green – Yes
Red – No
Yellow – Maybe

(Blue – Buffers)

Advanced Engineering & Sciences

Modeling & Simulation

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Fixed Site vs. Maneuver Force Tool

Determine Threat and Met Range → **Create Hazard Cube** → Determine Constraints on Sensor Placement → Establish Optimization Criteria → Establish Optimization Range → Optimize

- 2004 proposal envisioned fixed-site tool
- New program requirements require maneuver force support tool
- New requirements place challenge on hazard cube creation task
  - How much time available
  - In-field computing resources
  - Access to world-wide (or AOR) terrain databases

Options for Hazard Cube Creation

- Pre-run on *homestation* computers for entire region of interest and threat range
  - Likely very large data files
- Develop means to generate in theater to run on target CPU
  - Use METOC forecast as met input
  - How much time available?
  - Potentially lower fidelity
- Develop optimization schema that do not as rely as heavily on time-phases hazard transport phenomena
  - Dose/concentration grids
  - Need to address 3D phenomena for scanning standoff sensors (*e.g.*, JSLSCAD)

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SLOTS Will Exploit CB Dial-a-Sensor™ Modules for Sensor Optimization

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Determine Threat and Met Range → Create Hazard Cube → **Determine Constraints on Sensor Placement** → **Establish Optimization Criteria** → **Establish Optimization Range** → **Optimize**

- SLOTS will need to model CB sensors
- CB DAS's PuffTable sensor library will provide sensor modeling
  - Rugged taxonomy for CB sensor definition
    - Point and standoff CB sensors
    - Active and passive (integrating, imaging) CB sensors
    - Easily extensible for new sensor classes/types
  - Standard ANSI C++ (no OS-specific calls)
    - Readily compiled on new OS
- PuffTable is interoperable with SCIPUFF, VLSTRACK, and the architecture supports MESO. . . JEM
- PuffTable has undergone independent verification for ATEC

Optimization

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Genetic Algorithms & Sensor Location Optimization

- Decide where to deploy sensors within a given environment.
- Formulated as constrained optimization.
- Consists of three main elements:
  - ***Decision variables (solution)*:**
    - Typically modeled by X*ij* which is the number of sensor type *i* at location *j*.
    - We will restrict to allocating 1 sensor of any particular type to a particular location thus X*ij* will either be 0 or 1.
  - ***Objective/fitness function (performance criterion):***
    - Encodes the performance to be optimized, represented by either a maximization or minimization function (e.g., minimizing detection time).
    - We will utilize sensor characteristic models, terrain, plausible threat attack strategies, met conditions, and agent transport models to evaluate a sensor emplacement scheme’s performance.
  - ***Constraints*:**
    - Aspects which bound a feasible solution set.
    - Example constraints: sensor exclusion zones, critical friendly protection areas, sensor availability, and other SME extracted heuristics.

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Genetic Algorithm-based Sensor Location

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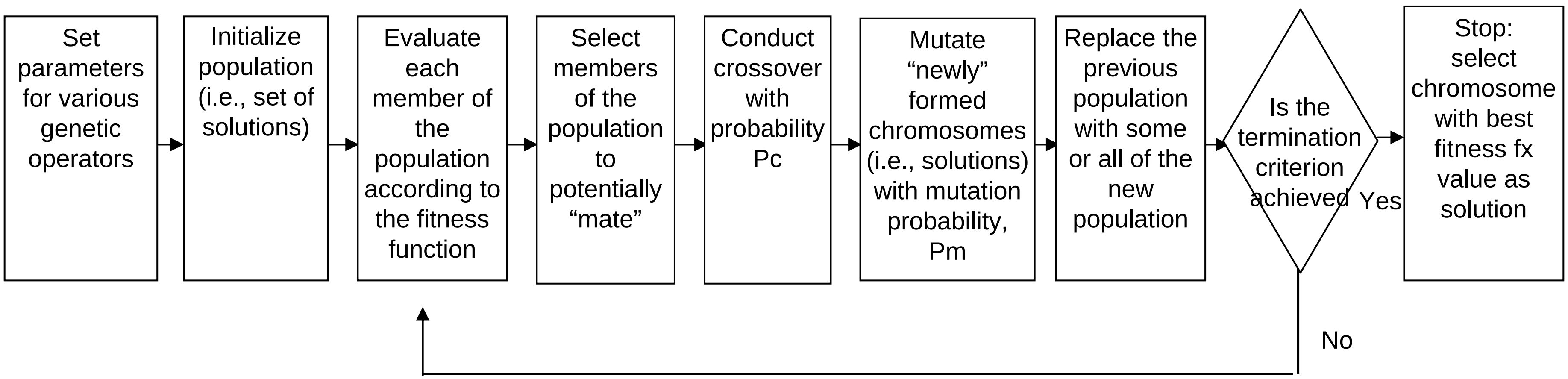

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SLOTS

SLOTS Genetic Algorithm Research & Development Effort

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- **General GA Research**
  - Research GA implementation in similar optimization problems
  - Extract knowledge to enhance our problem modeling, effectiveness, & efficiency
- **Performance Criterion (i.e., fitness function):**
  - Decide upon the performance criterion
  - Investigate the best method for fitness function evaluation
- **Constraint Handling**:
  - Capture and document domain knowledge and heuristics that will serve as the basis for the constraint set
  - Investigate GA specific constraint handling techniques
  - Select the best technique and model the constraints
- **GA Operators:**
  - Investigate various state of the art GA operators for implementing:
    - Population Size
    - Selection
    - Crossover
    - Mutation
    - Replacement
- **Develop and encode a genetic algorithm to optimize sensor location.**

Year 1

- Conduct Survey of SMEs
- Publish Sensor Placement Handbook

- AODB to CBRN DB Migration Plan
- Constraint identification and modeling
- Wind flow over complex terrain
- SCIPUFF generated transport and dispersion
- Homogeneous chemical point sensor matrix
  - Also, proposed heterogeneous chemical point sensor matrix
- Optimization based on single fitness function (TBD) (e.g., probability of detection)
- Extend to biological point sensor matrix

Summary

- Lots of research to do.
- Starting with the end in mind
  - JOEF Requirements

Questions?

SENSOR LOCATION AND OPTIMIZATION TOOL SET (SLOTS)

Michael J. Smith, Javad Sedehi, Stuart Edick, Mark Henning, William Crocoll
ITT Industries Advanced Engineering & Sciences

Abstract

With the proliferation of chemical and biological (CB) weapons, warfighter force protection, critical infrastructure defense, and installation protection are crucial aspects of today's battlespace preparation. Warfighters and analysts require decision support tools which can assist them in planning for force protection from these CB threats. These tools must ultimately support CB sensor optimization in terms of placement, sensor mix (point and standoff sensor systems), and existing C4 information analysis. SLOTS will model hazard movement over 3D terrain based on threat input and weather. It will then produce a sensor placement scheme based on agent dispersion characteristics, sensor characteristics, a sensor employment constraint set, and a predefined performance criterion (or set of criteria). Sensor placement heuristics will be used to form the constraint set. Models of the sensors, terrain, and agent transport will be used to generate data for evaluating the sensor placement schemes according to the specified performance criterion. Genetic Algorithms (GA) will be used to generate the sensor placement schemes. This effort will provide analysts and commanders with higher confidence in the monitoring capability of deployed sensors. The result will be a deployable, easy to operate tool that enhances the usability and reliability of deployed sensors into the larger concept of operations for CB protection.

Introduction

The relevance of a chemical and biological defense equipment development effort is measured, in part, by its ability to provide capability in one or more of the Joint Requirements Office's Chemical Biological Radiological and Nuclear (CBRN) core element areas - *Sense, Shape, Shield or Sustain*. Clearly the development and subsequent employment of detection systems largely contributes to our ability to *Sense* and to some extent *Shape* the battlespace. Our ability to accomplish this requires an extensive understanding of the interplay of the operational and technical challenges in employing sensor arrays to support detection, identification, and quantification of CBRN hazards.

While sensor technology continues to advance, chemical units are often limited in the number and types of sensor they are assigned. The challenge becomes understanding how to configure the sensors "in hand" to best accomplish the units mission. CB experts have evolved a set of rules governing this aspect of the *Sense* mission, grown out of years of experience. Many of the considerations for sensor placement are captured in doctrine and tactics techniques and procedures (TTP). Corollaries to these rules exist in the form of rules of thumb and lessons learned. The application of these rules in the field requires units to extrapolate between the ideal and reality. There is no method to optimize sensor distribution in real time to maximize the probability of mission success.

To this end the Joint Science and Technology program has funded the development of the Sensor Location and Optimization Tool Set or SLOTS. SLOTS will provide users with a tool that automates the process of sensor emplacement in the battlespace and will optimize the sensor placement solution based on user selectable parameters. The outcome will be a sensor employment plan, derived from convolving rules and high fidelity simulation of the environment and sensor performance, and applying advance artificial intelligence.

Background

Sense provides commanders with relevant hazard information at a specific time and place. Basic to *Sense* is the ability to employ sensor arrays to fulfill a commander's critical information requirements (CCIRs) regarding battlespace CBRN hazards. Complicating this objective is the reality of limited resources, technical and practical limitations, limited availability of analyst with required subject matter expertise, and the context in which sensors are employed. The question regarding what is the appropriate selection of sensors types, numbers, and locations depends on the interaction of the commander's intent or the mission, the enemy, terrain, troops, time and civilians (METT-TC), and available sensors. The chemical, biological, radiological, nuclear vulnerability assessment (CBRN VA) process provides a framework to answer the commander's priority intelligence requirements in support of the planning and execution of operations. Chemical units will know which and how many sensors they have based on the military table of equipment. By walking through the CBRN VA process they can hone in on the other factors associated with where to place them. The determination of the operational activity along the operational continuum (contiguous area of operations (AO) versus noncontiguous AO, fixed installation, temporary fixed installation - FOB, BSA, Firm, EAF, LOTS, or units maneuvering) establishes the context for sensor placement. This action designates the physical parameters of the problem space, taking

it from the information environment, and begins the process of identifying named areas of interest (NAI), areas where the threat must be delivered to be effective, relevant to the high value assets requiring sensor coverage. An understanding of mission and key assets (people and equipment), in turn, dictates the avoidance, protection, and decon courses of action available to a commander and the CCIRs necessary to make decisions. This information forms the basis for developing fitness functions that will enable SLOTS to speak to the relative efficiency of different sensor arrays (types, number, and location). Additionally, the selection of AO, unit, and mission narrows the field of the end users and the time lines associated with their planning cycle. This information is critical to designing SLOTS graphical user interfaces (GUIs), processing (power and speed) requirements, and optimization algorithms.

Threat, analyzed during the first part of the CBRN VA process, constitutes a major data source of the sensor placement equation, as the agent type and method of dissemination will determine what sensors, under what conditions, can detect a hazard release, determine NAIs, and therefore determine "detect to" capabilities and limitations. Vapor hazards associated with non-persistent agents and liquid hazards resulting from persistent agents will trigger different sensors based on the type and detection threshold. An understanding of the enemy's order of battle detailing CBRN agents and methods of delivery, along with concept of employment limits the potential threat array. When considering non-state actor's NBC threats, consideration will have to be given to periods when weather is favorable for the release of agents, and will help shape NAIs for this type of threat. The result is a subset of threats that represent the answer as to **what is to be detected**. The characterization of the hazard release (liquid and vapor and concentration) will determine what is detectable and by **what type of sensor**. The fill rate associated with these weapons and cumulative hazard generated by a point or line source will help to define **the NAIs that will require protecting**. Finally, we are left with the question of **where to place the sensors**.

Sensor Location Optimization Tool Set

The initial effort of the SLOTS program will be to capture the set of heuristics that govern the emplacement of sensors in the battlespace. The SLOTS Handbook will be a compilation of these heuristics, reviewed and validated by subject matter experts in the Chemical and Biological Defense community. Aside from the benefit of producing a concise compendium of these heuristics, gathering this information will be the basis for the development of an automated application, SLOTS, that guides users through the CBRN VA process. The SLOTS GUI will walk the users through a decision tree, and

pose questions that allow SLOTS to refine the outcomes of the NBC threat and vulnerability analysis. This will provide data necessary for use in vulnerability reduction measures—sensor placement.

Additionally, these user inputs will produce the data necessary to feed our models to provide the appropriate environmental context. Using SCIPUFF to generate the hazard threat (taking into account complex terrain and meteorological conditions) convolved with the mission data resulting from the CBRN VA and the CCIR bounding this process, SLOTS will generate a first order sensor deployment plan. Key to this operation is the ability to represent the performance of the array of sensor systems available to the commander. In going through the CBRN VA process, the sensor types required to support the mission, and the allocation of these is determined. SLOTS will utilize components of the Chemical Biological Dial-A-Sensor ™ or CB DAS to simulate the performance of a given sensor system. CB DAS is a component of the ITT Industries developed CB Simulation Suite, and provides a high level performance representation of most classes of available sensors. CB DAS can be easily extended to include new sensors, or conceptual sensor types.

During the SLOTS development effort, the results of automating sensor placement will be reviewed by Chemical Soldiers (some of the aforementioned SMEs). These Soldiers will be asked to employ the techniques outlined in doctrine and TTPs to arrive at a sensor placement plan for a sample mission. This same mission will be run through the SLOTS application. The result will be compared. This provides an initial verification of the process automation. Until this point automation has been the main thrust of the effort. Sensor placement plan optimization is the ultimate objective for the SLOTS, employing advanced artificial intelligence (AI) techniques. Verification of our process automation is critical, since with most AI techniques, the validity of the results is limited by that of the inputs (garbage in – garbage out).

To optimize our solutions, genetic algorithms (GA) will be used to generate the sensor placement schemes. This global solution space search technique is well suited for solving complex optimization problems generally stated as: given a set of N possible solutions, find the subset of M solutions to optimize some pre-determined measure of performance subject to certain constraints. Such is the case in determining where sensors need to be placed. A genetic algorithm is initialized by generating a large number of solutions to the problem and it then searches for improved solutions via biological evolution principles. Solutions are selectively recombined and stochastically altered to produce increasingly better solutions and weeding out poor ones to converge on a near optimal solution as determined by a performance criterion. Other optimization approaches that could be used to attack this problem include:

complete enumeration (i.e., exhaustive search), gradient descent, and heuristic methods. For large, realistic problems, exhaustive search suffers from combinatorial explosion while a gradient descent approach can be problematic due to local maxima (minima) and discontinuities in the search space. Thus a heuristic technique such as a genetic algorithm is an attractive alternative (Padula and Kincaid, 1999).

A genetic algorithm (GA) searches for solutions via the biological evolution principles of Natural Selection (i.e., survival of the fittest, crossbreeding, and mutation). The term genetic algorithm comes from fact that solutions are represented as strings of values analogous to chromosomes and genes. A GA starts with a set of initial solutions (typically via random solution generation) and produces increasingly better solutions by selectively combining (called crossover in GA terms) and stochastically altering (called mutation in GA terminology) existing solutions and weeding out poor ones to converge on a near optimal solution as determined by a specified performance criterion (referred to as the fitness function). This amounts to searching a large multidimensional (and possibly discontinuous) search space to find the solution with the best fitness function value. The general genetic algorithm procedure is represented in Figure 1 (Mitchell, 1997). The following provides a detailed description of the GA process and how it would be implemented for the sensor placement problem.

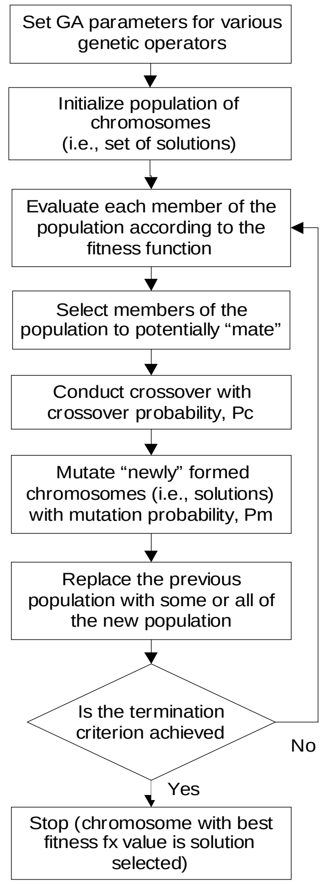

Figure 1. The basic genetic algorithm procedure

Sensor Placement using Genetic Algorithms

To reiterate, the objective of SLOTS is to provide an analyst with the tools to optimize the placement of a set of sensors given certain environmental conditions and employment factors. The proposed research will employ a genetic algorithm to search the sensor location space, subject to constraints, with the overall sensor placement scheme being evaluated according to a optimization criteria. We will develop the capability to define and generate a large grid representing potential sensor locations which will be linked to the transport model representing the dispersal of agent influenced by terrain and meteorological conditions as well as agent attack scenarios (Dhillon, Chakrabarty, and Iyengar, 2002). This will facilitate the evaluation of sensor placement schemes according to the specified fitness function. The granularity of the grid (distance between consecutive grid points) will be determined by the accuracy with which the sensor placement is desired. Methods will be developed to visualize the

transport data in conjunction with the sensor placement scheme. The remainder of this section walks through the implementation of a genetic algorithm describing the process and how it would be implemented for developing sensor placement schemes.

The first step in the GA process is to determine the structure of the solution and encode it as a string of values representing the decision variables associated with the problem. In the case of sensor placement, the solution represents the placement of sensors (similar ones in the homogeneous case and different ones in the heterogeneous case) within an NxM dimensional grid overlaid on a piece of terrain. One traditional sensor placement scheme would be to encode the genetic algorithm as a chromosome with each gene in the chromosome representing the presence or absence of sensor i at location j. Figure 2 illustrates an example of a solution structure for two sensor types within a simple 2x2 grid (1 represents the presence of the sensor at a particular location, while a 0 represents its absence).

Sensor A Loc 1,1	Sensor A Loc 1,2	Sensor A Loc 2,1	Sensor A Loc 2,2	Sensor B Loc 1,1	Sensor B Loc 1,2	Sensor B Loc 2,1	Sensor B Loc 2,2
0	0	0	1	0	0	1	0

Figure 2. Example Sensor Placement Solution Structure for Two Sensors

However, this representation exhibits similar problems to that of the exhaustive search in that it suffers from combinatorial explosion as the grid granularity increases. Additionally traditional mutation operations such as “flip a bit” tend to result in invalid solutions where sensors appear and disappear.

An alternate gene encoding is much more practical for this solution space. Consider a grid of N x M, and an array of sensors (p of type A and q of type B). A locator function provides an integer identifier for a grid space, such that a position of x,y returns the value of y * M + x . With this locator transformation, the chromosome is represented as a single array of integers size p + q. The simple 2x2 grid now would be encoded as shown in Figure 3.

Sensor A (Loc 2,2)	Sensor B Loc 2,1
4	3

Figure 3. Alternate Example Sensor Placement Solution Structure for Two Sensors

Aside from the obvious physical memory savings of this representation, additional gains include the ability to perform meaningful "mutation" operations such as "Move Sensor A one location to the West (subtract one from its current location)" and "Move Sensor B one location to the South (add N to its current location)"

The following example illustrates why an exhaustive search methodology is inappropriate for a modestly sized problem (let alone a more realistically sized problem). Let us assume we have 3 different sensors and a 5x5 grid. The upper bound on potential solutions would be 3.78x1022 (under the assumption that a sensor 'could' be placed at every point in the grid). Even if a computer could provide 1 million calculations a second, it would take over a billion years to evaluate every one of the potential solutions to determine the optimal sensor placement scheme. This clearly illustrates the need for a heuristic technique for solving 'real world' problems in an appropriate timeframe.

The solution set (i.e., collection of chromosomes) is called the population. The initial population is composed of a large (typically ranging from 100 to 1000) diverse (randomly created) set of solutions. An initial population of solutions will be generated, consisting of multiple potential sensor placement schemes.

Each solution (i.e., chromosome) in the population is then evaluated by a defined performance criterion (i.e., fitness function). The fitness reflects how well the sensor placement scheme solves the problem. Various sensor placement scheme performance criteria will be considered with a subset being investigated during this research. The fitness function value is then recorded for each solution in the population.

This step creates a 'breeding population' by selecting, probabilistically from the population based on their fitness function value, those solutions to selectively combine (i.e., chromosomes who will 'mate') and how often. The selection process provides the better solutions an increased chance to combine while also affording (albeit with a lower probability) less fit members (with potentially critical characteristics) an opportunity to mate as well. Popular selection techniques include the Weighted Roulette Wheel, Rank Selection, and Tournament Selection. During this step, sensor placement solutions will be selected to combine with other sensor placement solutions to create new sensor placement solutions. The manner is which those solutions are combined is addressed next.

In order to improve the current sensor placement solution set (i.e., population), genetic algorithms commonly use two genetic operations called crossover and mutation. Crossover can be viewed as an operation promoting genetic qualities that are already present in the population. Conversely, mutation promotes diversity within the population by introducing new qualities in an attempt to increase fitness.

The crossover operation exchanges information from two 'parent' solutions (i.e., chromosomes) from the breeding population. Typical crossover methods include Single-point, Two-point, and Uniform. Figure 4 illustrates how Single-point crossover would work for a sensor placement example for two 'parent' solutions creating two 'child' solutions. The crossover point is selected at random and crossover is conducted by exchanging portions of the solution of the parents to create subsequent solutions (called children). This process is repeated 'population size' times.

Crossover Point

Parent 1	3	16	5	32	153	2	35	6
Parent 2	35	7	253	86	33	103	88	76
					CP			
Child 1	3	16	5	32	33	103	88	76
Child 2	35	7	253	86	153	2	35	6

Figure 4. Example of Single-point Crossover for Eight Sensor Solutions

Since crossover can only rearrange information already in the solutions, mutation (i.e., stochastic altering) is a method that circumvents this problem, allowing the examination of potentially fruitful portions of the solution space. Once child solutions are created, the mutation operator can randomly change portions of the solution (i.e., genes) in the children with some, typically, very low probability (e.g., .001). Figure 5 illustrates the mutation of gene 3 of Child 1 in Figure 4. This is equivalent to moving the third sensor in the array one grid cell to the

Child 1	3	16	5	32	33	103	88	76
Child 1'	3	16	6	32	33	103	88	76

Figure 5. Example of Mutation of a Solution

The previous set of sensor placement solutions (i.e., generation) will then be replaced with the new solutions via a replacement strategy. Replacement is the manner in which the next set of solutions (i.e., chromosomes) is determined. Replacement techniques include: Generational (i.e., replace the entire previous population), Elitist (always retain the most fit chromosome), Steady State (replace a small portion of the population), and Steady State without duplicates.

The genetic algorithm process steps continue until a termination criterion is achieved. There typically are five common termination criteria from which to select:

- When the population has converged largely to a single chromosome.
- When improvement in the average fitness (or maximum fitness) of the population has leveled off.
- When a predetermined number of generations has occurred.
- When a certain amount of time has elapsed.
- When a solution meets or exceeds some measure of fitness.

Once the termination criterion is achieved, the solution (i.e., chromosome) with the best fitness function value provides the sensor placement solution.

The use of genetic algorithms for sensor placement is novel within the Chemical Biological Defense arena. However, GAs have successfully been employed in wireless communication node placement applications and a growing list of other successful implementations. The SLOTS development effort will make use of an existing genetic algorithm library developed by Professor Matthew Wall at Massachusetts Institute of Technology. Professor Wall's, **GAlib**, has been used in a number of commercial, government and academic products, such as Intuit's financial products and SAS/MarketMax's retail space planning system. Because GAlib is at the heart of these larger user-base applications it is extremely well documented.

Conclusion

The SLOTS development team has a few challenges to be addressed during the two year development period. The goal of this effort is to deliver a tool that optimizes sensor placement based on militarily relevant fitness functions. These may vary from – "minimizing time to detect" to "maximizing the probability of detection" and then combinations thereof, all within the bounds of the appropriate operational constraints. This aspect places huge requirements on the underlying architecture and software design, for SLOTS to have the broadest application. Aside from the technical aspects of producing a

software tool that is user friendly, meets all the runtime, operating system, and network worthiness requirements significant deliberation will be focused on determining how good is the SLOTS final solution. A failing of GA applications is the tendency to converge on false-maxima. To safeguard against this behavior, a process for validating solutions will be developed.

The SLOTS effort will develop a sensor placement and optimization tool capable of supporting the warfighter and analysts in generating a sensor placement plan to best accomplish the *Sense* mission, protecting the force and critical assets. SLOTS will offer a structured and repeatable automated methodology to achieve optimized sensor placement in support of deliberate planning, and by extension resource allocation studies. This development will leverage previous accomplishments in CB sensor and hazard transport modeling, applied artificial intelligence, and software engineering.

Acknowledgements

The authors would like to thank Professor Matthew Wall, Massachusetts Institute of Technology, for his assistance and support.

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Applying Quantum Chemical Theory to the Fate of Chemical Warfare Agents

S&T CBIS Conference

Presented By

Tom J. Evans, Ph.D.
Tom Stark, Ph.D.
Cubic Applications, Inc.

26 October 2005

Agent Fate Program

- Five year DTO investigating the persistence and fate of chemical warfare agents (CWA)
- Major activity - generation and collection of accurate evaporation data derived from laboratory, bench scale experiments to open air field trials.
- Historically, data collection has consisted of factorial experiments to empirically measure the evaporation response.

Agent Fate Program

- Historical approach consisted of factorial-type experiments to collect data on agent persistency/behavior
  - Large number of potential factors
  - Many factor levels
- Even with statistical DOE techniques the number of permutations is very large.

Short Comings To Experimental Approach

- Impossible to do studies with **ALL** permutations of known/immerging threats and surfaces of interest
- Limited/no use of agents in the field
- Risk & cost associated with any agent work
- Rate of emerging threats is conceivably faster than rate of traditional approach to investigate

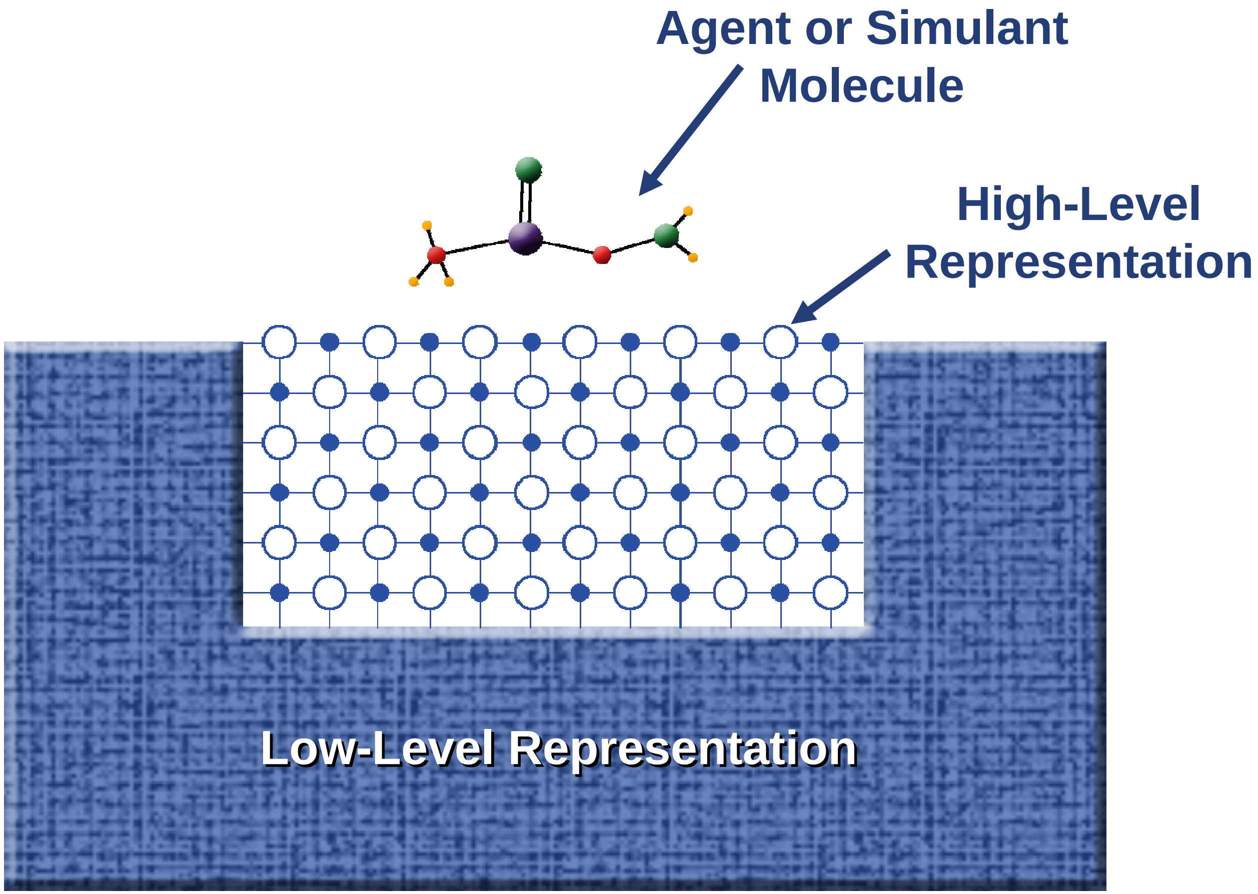
The Heart of the Problem

- Understanding fundamental principles
  - Streamlines current and future efforts
  - Directs experimental design on existing threats
  - Reduces the number of experiments for agent/substrate combinations
  - Focuses efforts as new threats immerge – helps deal with a “technical surprise”
- Much of experimental work is done with simulants
  - Need to determine reliability of simulant for representing agent
  - Data from agent/substrate and simulant/substrate can be compared side-by-side

Quantum Chemistry Calculations Important Points

- Quantum Chemical Theory (QCT) – Embedded Cluster
- QCT enhances but does not replace experimental efforts
- Surfaces of interest
  - Selected because they are well understood
  - Representative of more complex surfaces and materials
- Only recently have HPC capabilities (speed and memory) allowed for these types of approaches

Embedded Cluster



Advantages of Embedded Clusters

- Tool to investigate interactions at molecular level
- Limits prohibitive cost of all high-level QCT surface calculations
- Represents surface at realistic level of approximation
- Long range effects of surrounding cluster present

Conclusions

- Effort to incorporate QCT into Agent Fate Program signifies more than another tool
  - Recognition that shortcomings of purely experimental data can be overcome by modeling
  - Efforts to make the overwhelming fate of agent problem are moving to understanding fundamental principles
- QCT can be used to streamline programs efforts, while making contributions that move beyond Agent Fate

Questions?

Chem-Bio Protection Without Chem-Bio Sensors:

Low Cost, Dual Use, Alternative Sensor and Information Architectures

Steven S. Streetman
ENSCO, Inc.
October 24, 2005

Overview / Disclaimer

- Current Sensor Capabilities / Limitations / Strategies
- Event Timelines
- Threats and Observables
- Alternate Detection Architectures for Overarching Detection Model
  - Acoustics
  - Radar
  - Video
  - Electro-Chemical
  - Procedural
- Summary

Current Sensor Performance

- Sensors Do Not Provide Protection
  - Sensors provide warning to enable protective measures
  - Warning MUST be sufficiently detailed and reliable to allow protective measures to be enabled
- Current Capabilities
  - Chem:
    - IMS / SAW provides detection and ID in seconds to minutes for agent present at sensor
    - FTIR provides detection, ID, bearing/location in seconds for agent at range
  - Bio:
    - Particle Count / UV Fluorescence provide bio/non-bio detection in seconds to minutes for agent present at sensor
    - Active laser provides bio/non-bio detection, bearing/location in seconds for agent at range
    - HHA / PCR provides bio presumptive ID in tens of minutes
    - Lab tests provide confirmed ID in hours

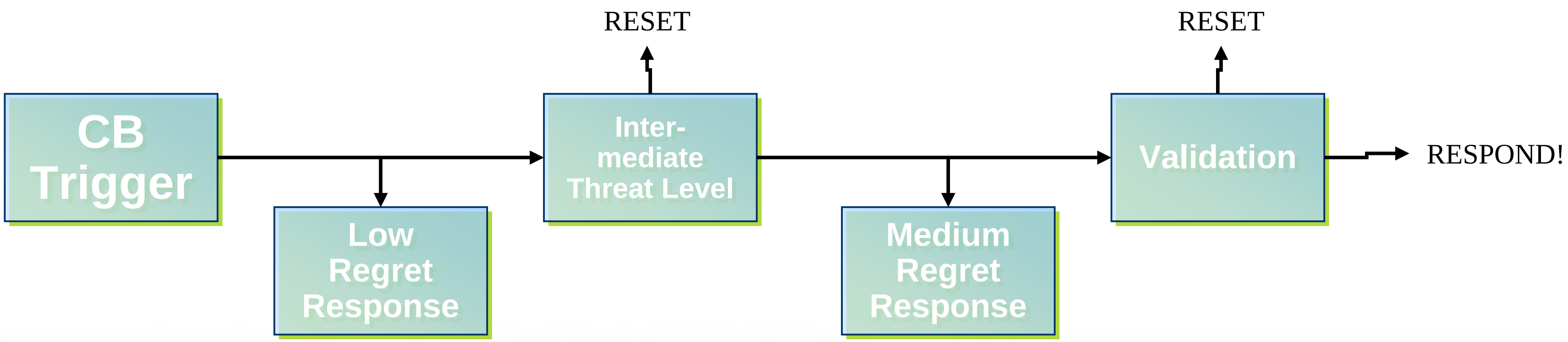
Current Sensor Limitations

- Breadth of Agents Detected
  - Chem: usually CWAs and a few TICs
  - Bio: specific agents tested (usually 5-10)
- Sensor Detection Range
  - Point sensors: range is effectively 0. Agent must be present at sensor air intake
  - Stand-off sensors: 1-50km
- Info Provided / Timeliness
  - No source location for point sensors
  - Id for detection sensors often not specific (e.g. bio vs. non-bio, agent class)
  - Detection / ID time too long
- Cost: Initial Cost High; Lifecycle Cost High
- False Alarms (Nuisance Alarms)
  - Sensors cannot reliably distinguish between normal chemical or biological sources and threat
  - Example: 19 month alarm data from operational system
    - Chemical Alarms: @260,000 alarms; 13,817 events (1 per hr)
    - Biological Alarms: @9,600 alarms; 4,869 events (8 per day)

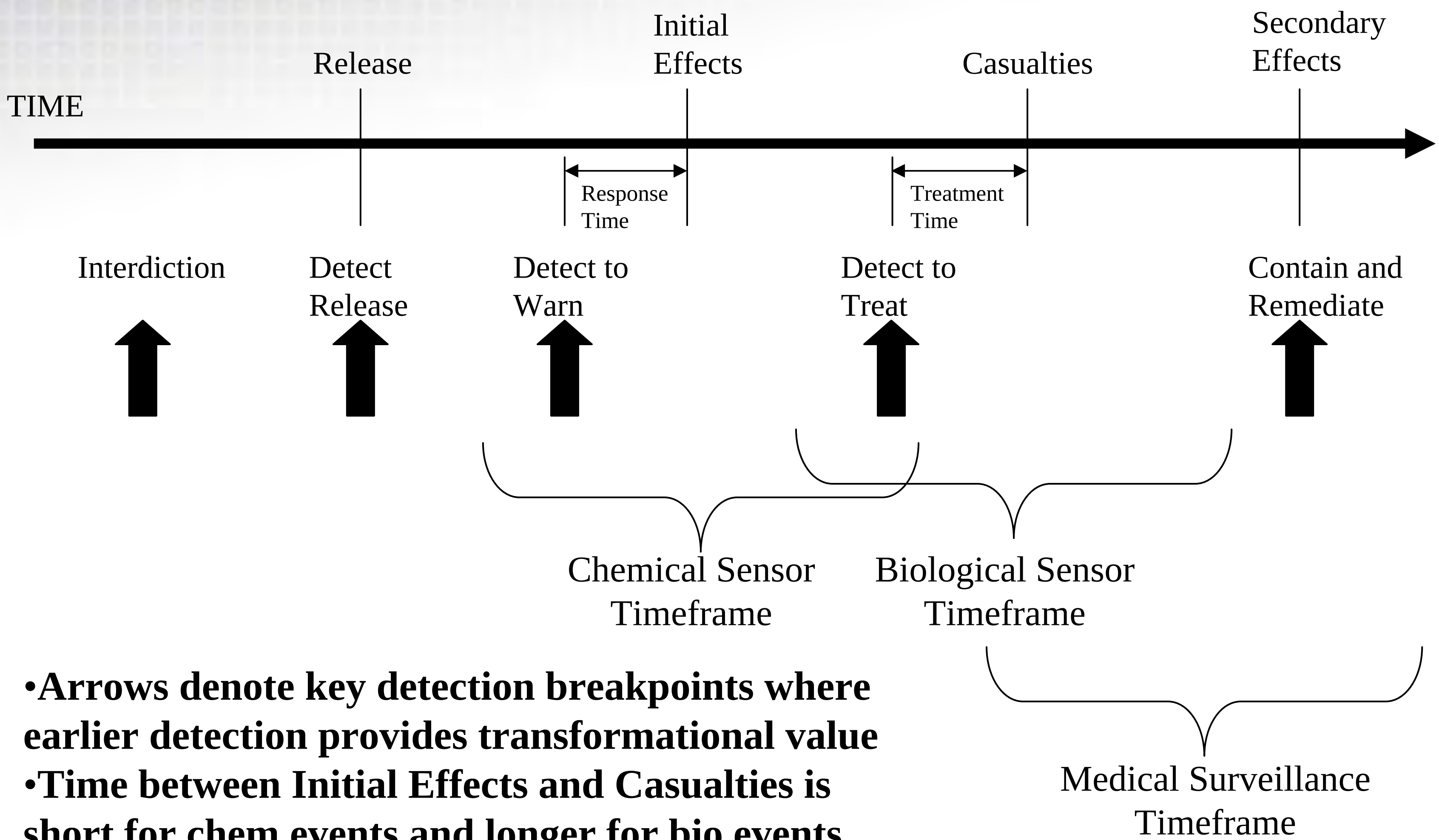
Operational Use of CBRN Sensors

- Cannot Implement Protective Responses Based on Chem-Bio Sensors Alone
- Validation Procedures
  - Threat Levels: graduated responses and information gathering
  - Multiple Phenomenologies:
    - redundant biological ID; lab tests
    - video / investigation for chem
    - Additional / alternate chemical sensors (e.g. handheld)
- Chem-Bio Sensors Become 'Triggers' for Validation Procedures

KEY QUESTION: Can We Use Alternative 'Triggers'?



Sensor Event Timeline



- **Arrows denote key detection breakpoints where earlier detection provides transformational value**
- **Time between Initial Effects and Casualties is short for chem events and longer for bio events**

Chemical Threats

THREAT	SIZE	CHEMICAL	LOCATION	AMOUNT	RELEASE
Industrial / Stored Chemical	Large	Known	Known	Known	Explosive
Rail Accident / Sabotage	Large	Known	Restricted to Rail Location	Known	Explosive / Derailment
Tanker Truck	Moderate	Possibly Known	Unknown / Possibly Restricted	Estimated	Spray / Explosive
Chemical Warfare Agent	Small	Unknown	Unknown	Unknown	Spray

Biological Threats

- Non-contagious
  - Large release
  - US Mail
- Contagious
  - Cougher
  - Contaminated products
- Location always unpredictable
- Agent type and amount unpredictable
- Small releases not detectable by any sensor type

Protection Options

- Perimeter Protection
  - Requires polices and procedures to implement; may require restrictions to flow of commerce
  - Pre-Event; not a response
- Collective Protection
  - Passive (not dependent on sensors)
  - Active (low regret response)
- Individual Protection Equipment (IPE)
  - Requires notification before exposure
  - Medium regret response
- Evacuation
  - Requires knowledge of agent location / transport
  - High regret response
- Decontamination
  - Requires knowledge of agent type / location
  - Medium to High regret response
- Treatment (e.g. antibiotics)
  - Requires knowledge of agent type / exposure
  - Medium to High regret response

Observables

- Threat / Intention
  - Communications
  - Web sites
  - Precursor purchase
- Release / Release Mechanism
  - Agent container/release mechanism
  - Smoke / cloud
  - Explosion
  - Traces of agent on container
  - Suspicious behavior
- Agent
  - Spectral signature
  - Florescence
  - Particle size
  - Cloud
- Agent Effects
  - Duress (animal or human)
  - Casualties
  - Treatments (treatment purchase)
  - Bleaching / material effects
  - Death

Alternative Detection Strategies

- Acoustics
  - Detect and locate explosion / derailment
- Radar
  - Detect and locate suspicious behavior in aircraft / watercraft
- Video
  - Detect duress, physical intrusion, smoke, suspicious activity
  - Also used for validation
- Electro-chemical sensors
  - Special purpose detection of known chemicals
- Procedures
  - Perimeter protection CONOPS
  - Data sharing (existing sensor data)
  - Source tracking (large, known chemical sources)

Acoustics

- Description
  - Small arrays of microphones with detection algorithms for explosive events
- Applicable Threats
  - Explosive releases of chem or bio agents
  - Derailments, sabotage using explosives
- Advantages
  - Detects release itself (earliest possible detection of release)
  - Provides standoff detection
  - Provides bearing/location and time of source release
- Disadvantages
  - Ineffective against spray releases or other non-explosive releases
- Dual Use
  - Gunshot / explosion detection
  - Situational awareness
- Cost
  - Low hundreds of dollars for purchase and installation
  - Largely maintenance free

Radar

- Description
  - Existing flight or surveillance radars along with procedures to identify suspicious behavior
- Applicable Threats
  - Air or Water vehicle releases
- Advantages
  - Detects release itself (earliest possible detection of release)
  - Provides standoff detection
  - Provides bearing/location and time of source release
- Disadvantages
  - Ineffective against small releases, planted explosives, or sabotage
- Dual Use
  - Intrusion Monitoring
  - Flight / maritime control and situational awareness
- Cost
  - Expensive, but often already installed in maritime or airport applications

Video

- Description
  - CCTV cameras installed at strategic areas and linked to command center
  - Intelligent video algorithms to identify events of interest
- Applicable Threats
  - Chemical releases with immediate effects on people or animals
  - Visible clouds or smoke
  - Threats that require physical intrusion (e.g into an air intake mechanical room)
- Advantages
  - Cameras are quickly becoming ubiquitous through physical security programs
  - Possible interdiction of event (in intrusion case)
  - Provides detailed visual evidence for situational awareness; may also be used for validation
  - Long range available
- Disadvantages
  - Intelligent video algorithms to detect smoke, visible clouds, or duress are immature and may false alarm
  - Requires line of site to event or event's effects
  - Possible day/night issues
- Dual Use
  - Situational awareness for all types of security and response applications
  - Detection of duress due to other causes than CB event
- Cost
  - Low hundreds of dollars for purchase and installation / Intelligent algorithms more expensive
  - Largely maintenance free

Electro-Chemical Sensors

- Description
  - Arrays of (typically 1-8) electro-chemical sensors each of which detects only a specific chemical
- Applicable Threats
  - Known agent at a known or restricted location
- Advantages
  - Detector placed near agent to detect release near release point (effectively standoff)
  - Extremely low false / nuisance alarm rate
  - Identifies source location through known storage location
- Disadvantages
  - Not effective against bio releases
  - Only effective against one agent per sensor
- Dual Use
  - Safety of hazardous chemical storage
  - Environmental sensing within a facility (e.g. radon / carbon-dioxide)
- Cost
  - Mid hundreds of dollars per chemical for purchase and installation
  - Moderate maintenance

Procedures

- Procedural changes provide opportunities to leverage existing detection capabilities or reduce vulnerabilities
- Examples:
  - Perimeter Interdiction
    - Vehicle Searches: swabbing sprayers or tanker trucks reduces ability to introduce quantities of agent to controlled area
    - ‘Trusted’ Personnel Programs (e.g. trusted shippers): identifies normal use of equipment / activities that are confusing sources for suspicious behavior and reduces impact on those activities from onerous procedures
  - Data Sharing
    - Existing data collection (e.g. chemical sensors at chemical plants) could be shared with EOC as part of situational awareness
  - Source Tracking
    - Implement a source tracking program for large chemical / biological hazardous materials similar to the tracking program for Level 1&2 radiation sources
    - Provides location and load information for large amounts of hazardous materials of all types

Summary

- CB sensors have limitations that, in an operational environment, require them to act as triggers to additional validation procedures
- Other detection capabilities exist that can act as CB triggers and can for some threats:
  - Detect earlier in the event timeline
  - Provide additional useful information such as source location
  - Detect broad spectrum of agents
- Alternate detection capabilities are typically:
  - Already deployed for other uses
  - Lower lifecycle cost than CB sensors
  - Have existing personnel to support
- Procedural additions can provide detection and/or validation capabilities without the cost of additional detectors

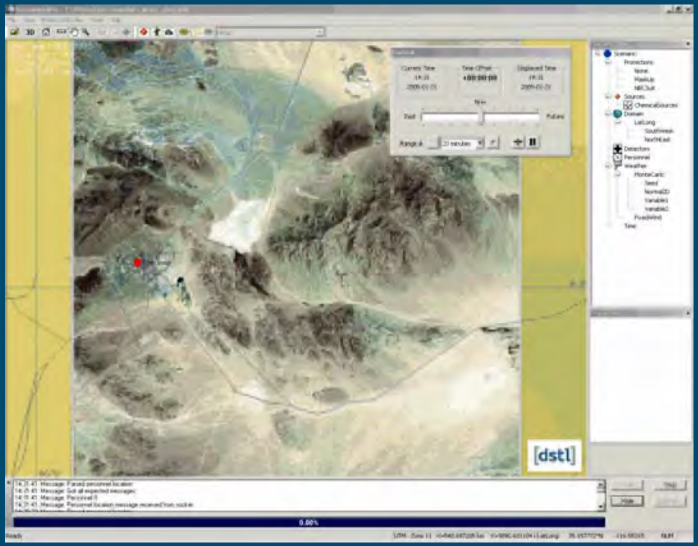
Alternate Detection Capabilities Should Be Evaluated To Replace or Augment Traditional CB Sensors in Specific Applications

CB Weapon Environment Prediction: Source Term Estimation

Paul Thomas,

Peter Robins, Ronni Rapley

Operational Need



- Operational strategy: base CBRN Hazard Estimates on dispersion models.
- Dispersion modelling is dependent on Source Term parameters
- For covert CBR releases, Source Terms will not be known
- Fast source term estimation needs to be performed
- An estimate of the uncertainty of the Source Term aids decision making

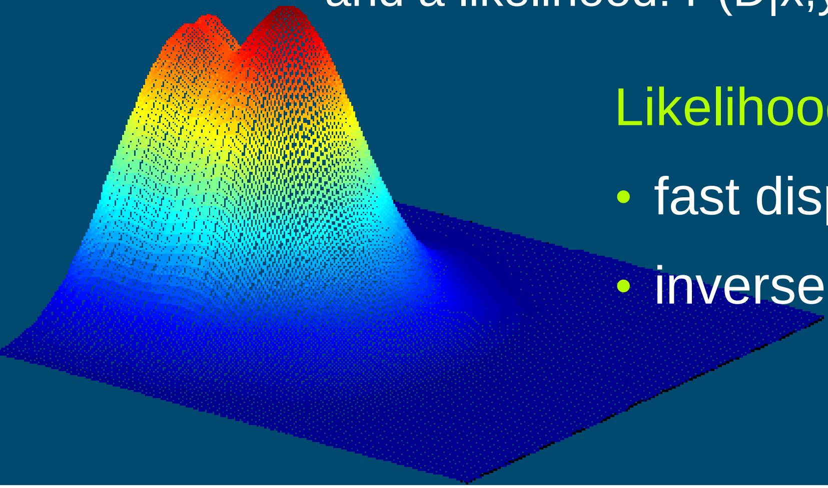
Introduction

Bayesian approach

- P(D|H) is generally intractable, instead we calculate relative probabilities
- to calculate probabilities of hypotheses P(x,y,Q,t,A|D), we need:
  - a prior: P(x,y,Q,t,A)
    - and a likelihood: P(D|x,y,Q,t,A)

$$P(H \mid \mathbf{D}) = \frac{P(\mathbf{D} \mid H)\,P(H)}{\sum_{H} P(\mathbf{D} \mid H)}$$

$$\frac{P(H_A \mid \mathbf{D})}{P(H_B \mid \mathbf{D})} = \frac{P(\mathbf{D} \mid H_A)\,P(H_A)}{P(\mathbf{D} \mid H_B)\,P(H_B)}$$

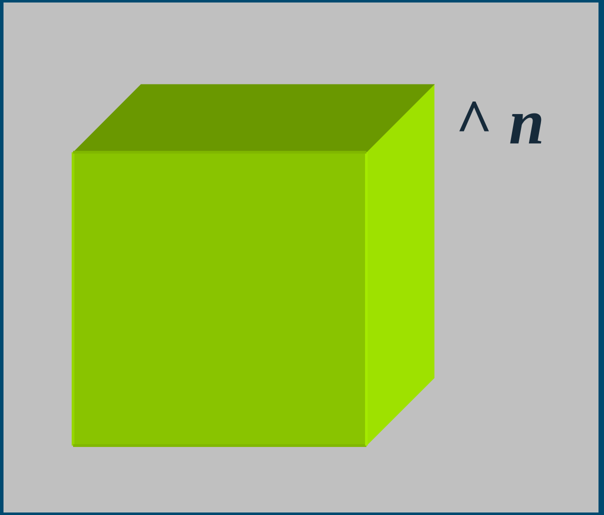


Likelihood calculation needs either:

- fast dispersion model
- inverse dispersion run

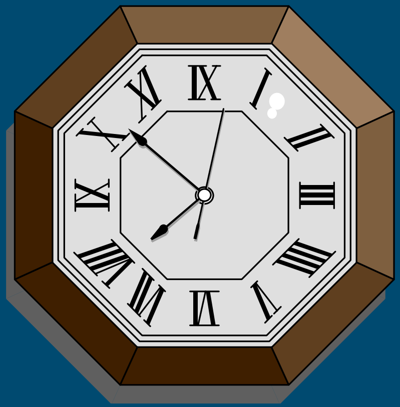
Technical Problems

- multidimensional search space;
  - sampling strategies to make efficient hypotheses in hypercube
- computational efficiency
- fixed / mobile sensors
- fusion of disparate data
- modelling sensor response
- biological source term estimation
- Evaluation of methodology



Technical Problems

- multidimensional search space;
- computational efficiency
  - target: source term estimation 5 minutes after first detection
- fixed / mobile sensors
- fusion of disparate data
- modelling sensor response
- biological source term estimation
- Evaluation of methodology



Technical Problems

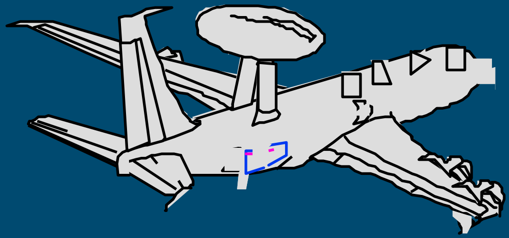
- multidimensional search space;
- computational efficiency
- fixed / mobile sensors
  - fixed sensors →high data rate.

Mobile sensors →position unknown

- fusion of disparate data
- modelling sensor response
- biological source term estimation
- Evaluation of methodology

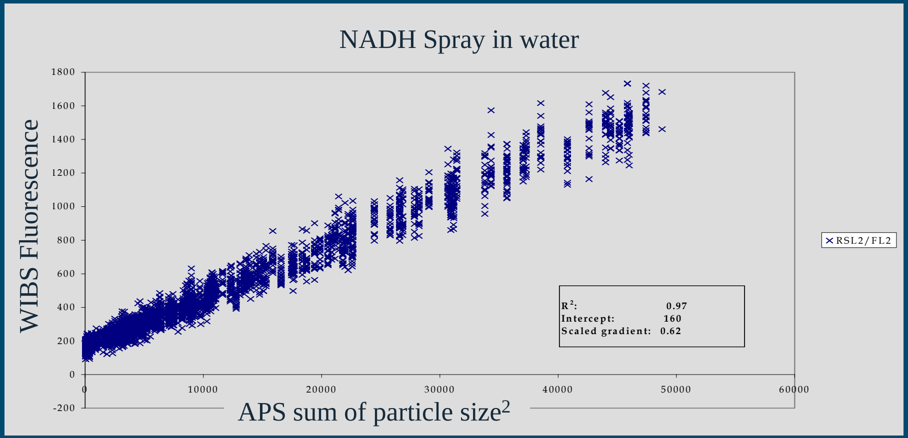
Technical Problems

- multidimensional search space;
- computational efficiency
- fixed / mobile sensors
- fusion of disparate data
  - e.g. human observations, ISTAR observations
- modelling sensor response
- biological source term estimation
- Evaluation of methodology



Technical Problems

- multidimensional search space;
- computational efficiency
- fixed / mobile sensors
- fusion of disparate data
- modelling sensor response
  - so that sensor uncertainty can be accounted for
- biological source term estimation
- Evaluation of methodology



Technical Problems

- multidimensional search space;
- computational efficiency
- fixed / mobile sensors
- fusion of disparate data
- modelling sensor response
- biological source term estimation
  - biological background leads to false alarms
- Evaluation of methodology

Technical Problems

- multidimensional search space;
- computational efficiency
- fixed / mobile sensors
- fusion of disparate data
- modelling sensor response
- biological source term estimation
- Evaluation of methodology
  - objective validation

Multidimensional Search Space

- Differential Evolution - Markov Chain
- On start-up several hypotheses, (we use 50) are distributed throughout the prior, these form the start of Markov Chains
- For each hypothesis, run the UDM to calculate the parameters of the clipped Gaussian (μ,σ)
- Then the probability/ weighting of each hypothesis can be calculated immediately data becomes available
- During ideal time, cycle through each Markov Chain in turn. New jumps are proposed from difference between chains

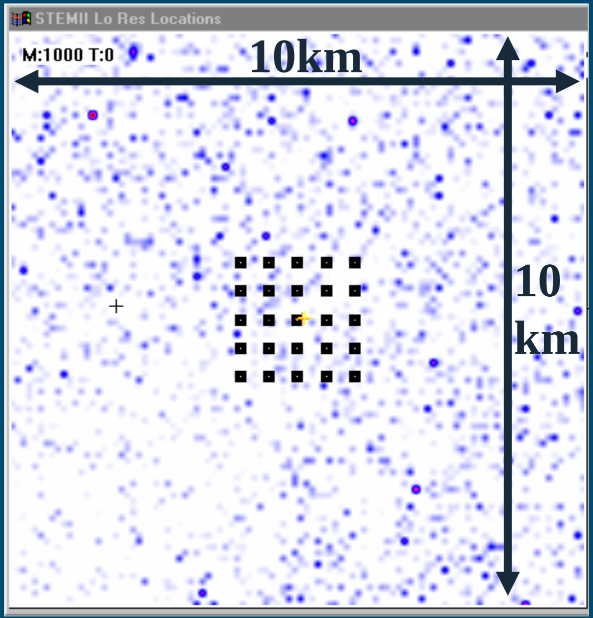
$$\mathbf{x}_{i,new} = \mathbf{x}_{i,old} + \gamma\left(\mathbf{x}_j - \mathbf{x}_k\right) + \varepsilon, \quad i \neq j \neq k$$

- Adaptive: Population mimics distribution (inc. correlations).
- Aggressive expansion from degeneracy.

Computational Efficiency

Idle time processing

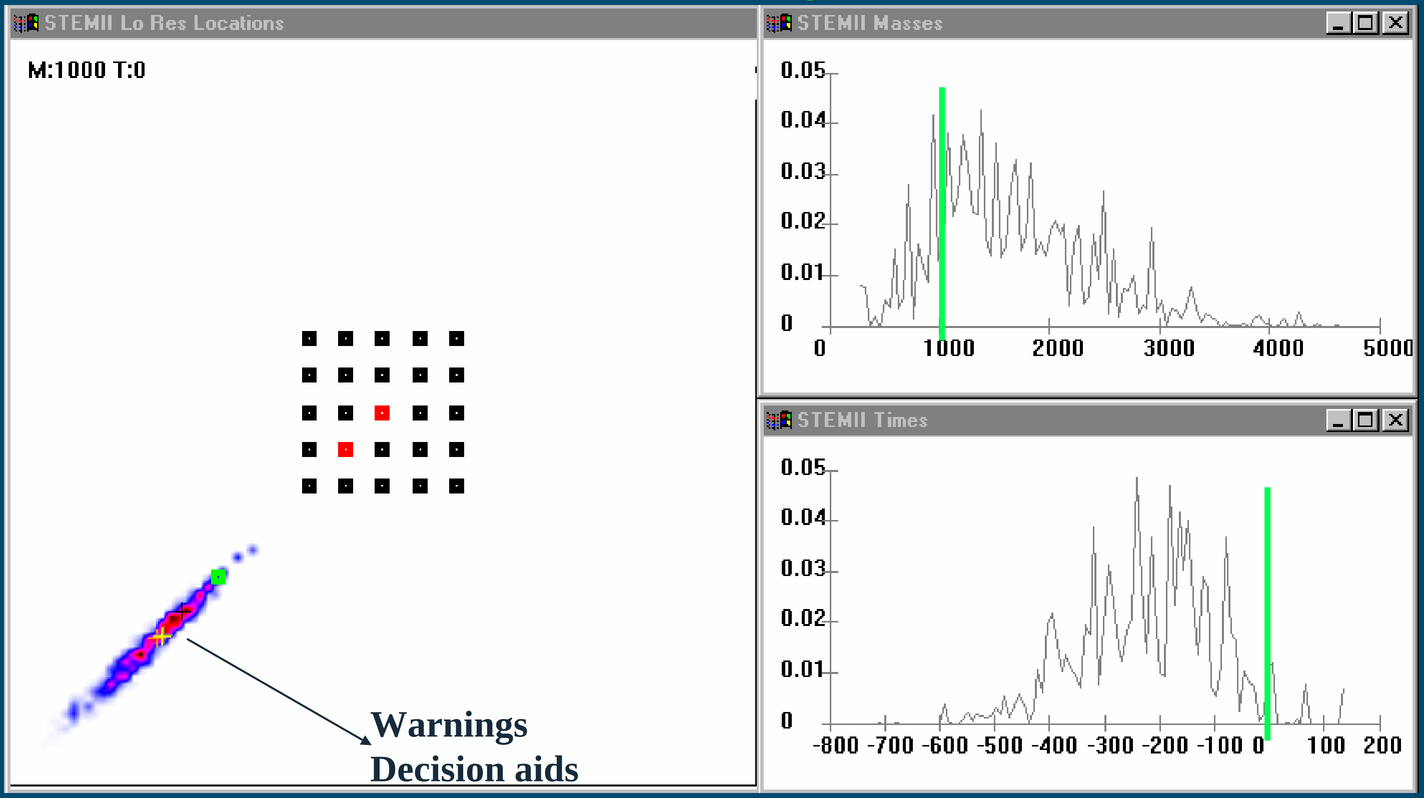
- Add new samples to map out posterior according to current data.
  - Propose new samples.
    - Differential Evolution – Markov Chain.
  - Two-Step Accept/reject.
- Check for data.
- Sample Importance Resample if:
  - Few hypotheses have significant weight.
  - Data process time rules out idle time.



Computational Efficiency

Chem scenario, fixed sensors

5 minutes after first sensor responds



Fixed / mobile sensors

- Fusion of data from mobile sensors

- Previously unreported sensors, e.g. with a manoeuvre unit
- No opportunity to perform pre-processing
- Alarm only (rather than bar reading or concentration)

Fixed / mobile sensors

- Fusion of data from mobile sensors

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- No opportunity to perform pre-processing
- Alarm only (rather than bar reading or concentration)

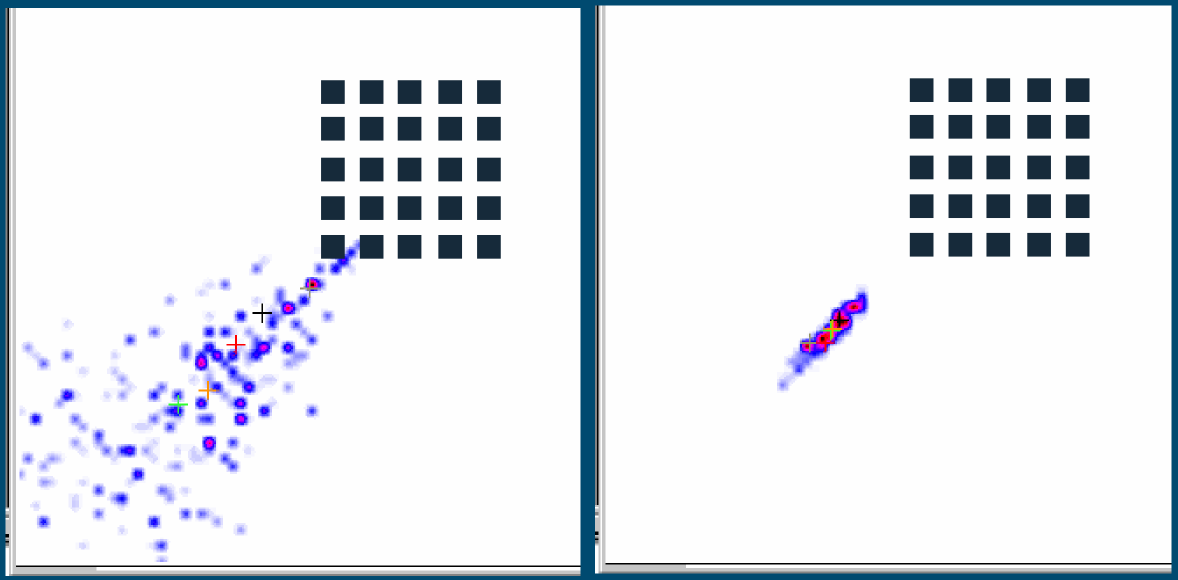
Solution:

- **Dispersion model adjoint**
- **Current simplifying assumptions include spatially homogeneous wind flow and terrain - in this case, the reversal of wind and time form an exact adjoint**

Human observations

- Human observation fusion

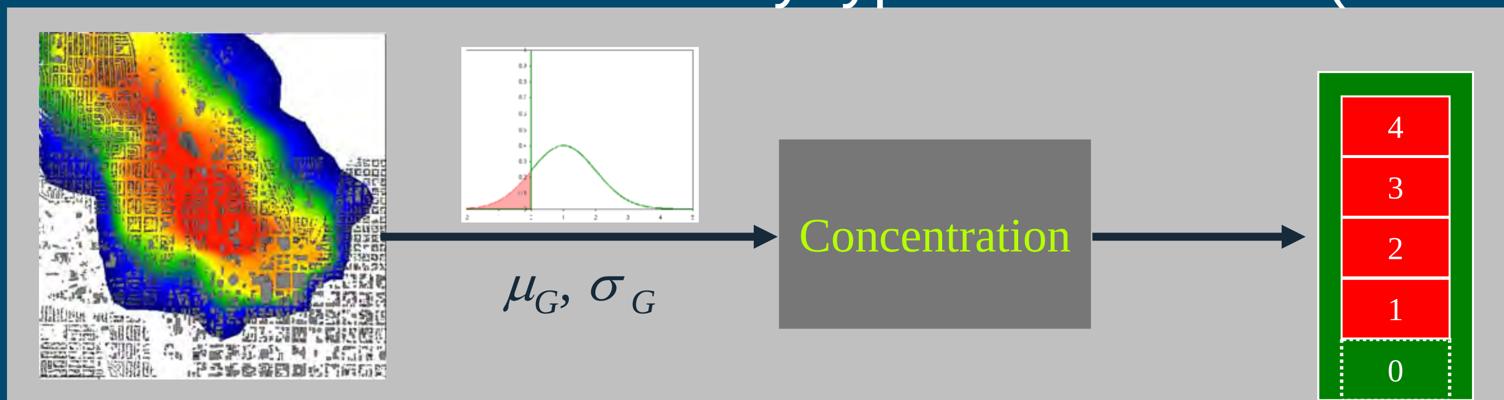
  - Either bearing-only or bearing and range



- **Bearing uncertainty modelled as Gaussian**
- **Range uncertainty modelled as Log-normal**

Sensor response models

- Probabilistic models of sensor response
  - Chemical sensor: Ion Mobility type “bar” sensor (≡ACADA)



- model P(bar|dispersion code output).

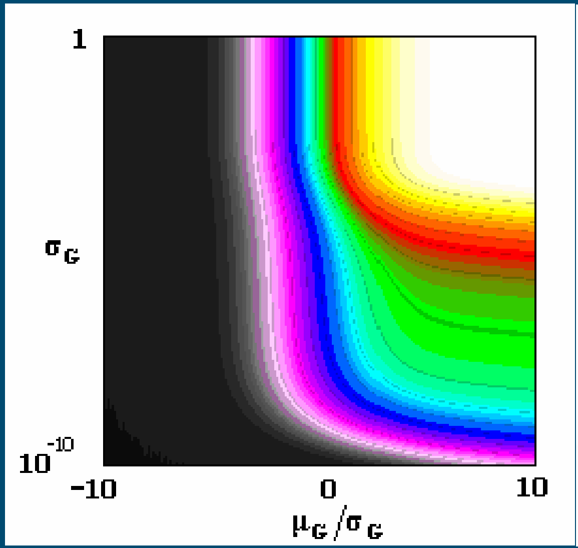
$$P\left(bar_i \mid \mu_G, \sigma_G\right) = \int_0^\infty P\left(bar_i \mid c\right) P\left(c \mid \mu_G, \sigma_G\right) dc$$

$$P\left(bar_i \mid \mu_N, \sigma_N^2\right) = \int_0^\infty \frac{1}{\sqrt{2\pi(\alpha c + J)}} \int_{T_{i-1}}^{T_i} e^{-\frac{1}{2}\frac{(V-c)^2}{(\alpha c+J)}} dV \left[\frac{1}{2}\left(1 - \operatorname{erf}\left(\frac{\mu_N}{\sigma_N\sqrt{2}}\right)\right)\delta(c) + \frac{1}{\sigma_N\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{c-\mu_N}{\sigma_N}\right)^2}\right] dc$$

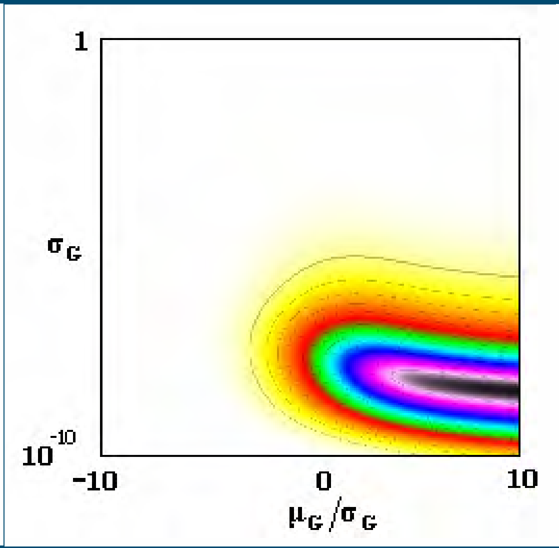
Sensor response models

- Probabilistic models of sensor response

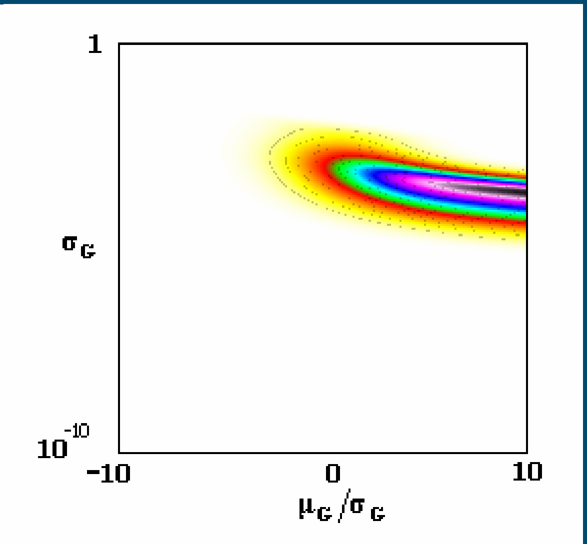
  - Look-up table of pre-computed integrals



0 bars



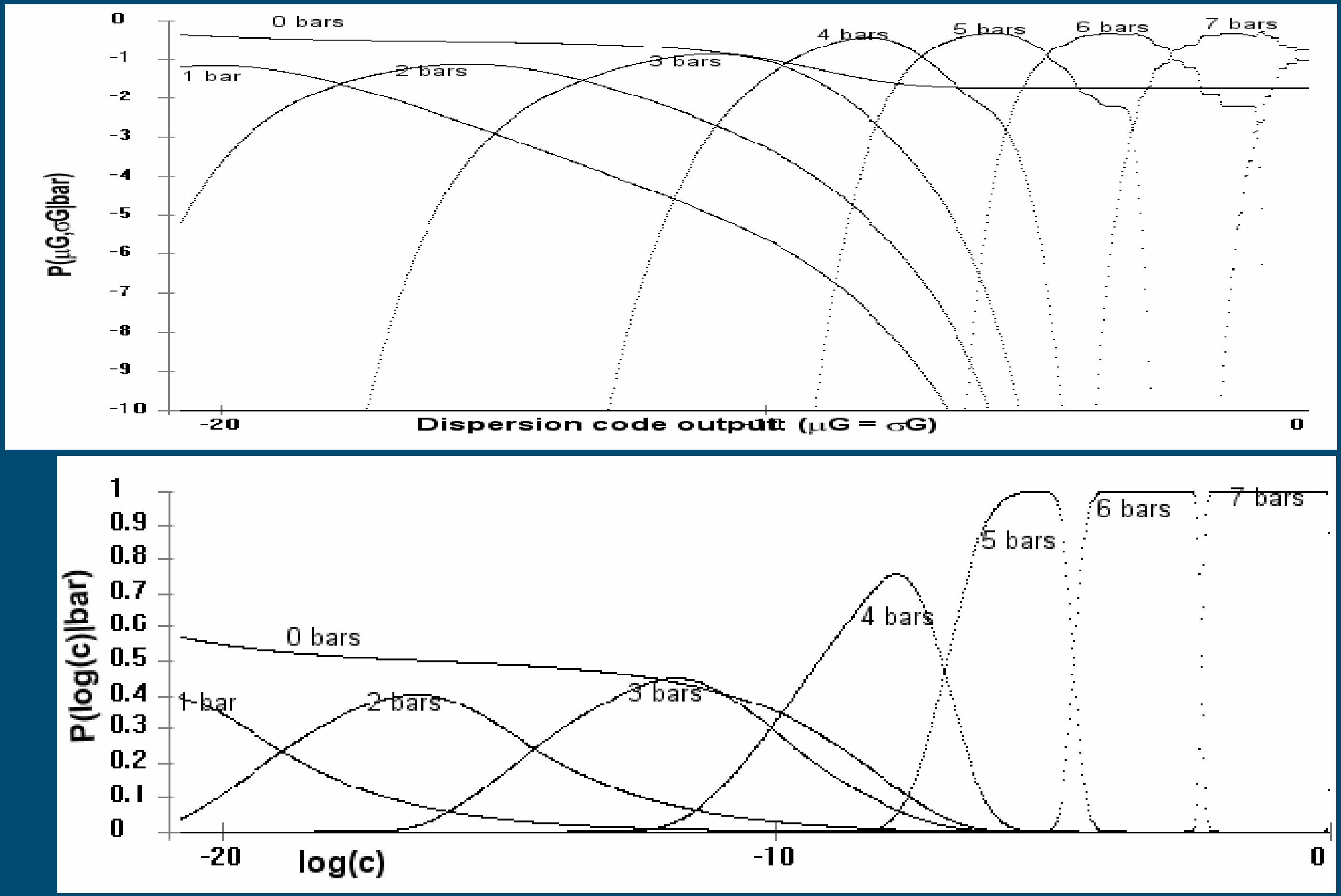
1 bar



4 bars

Sensor response models

- Probabilistic models of sensor response

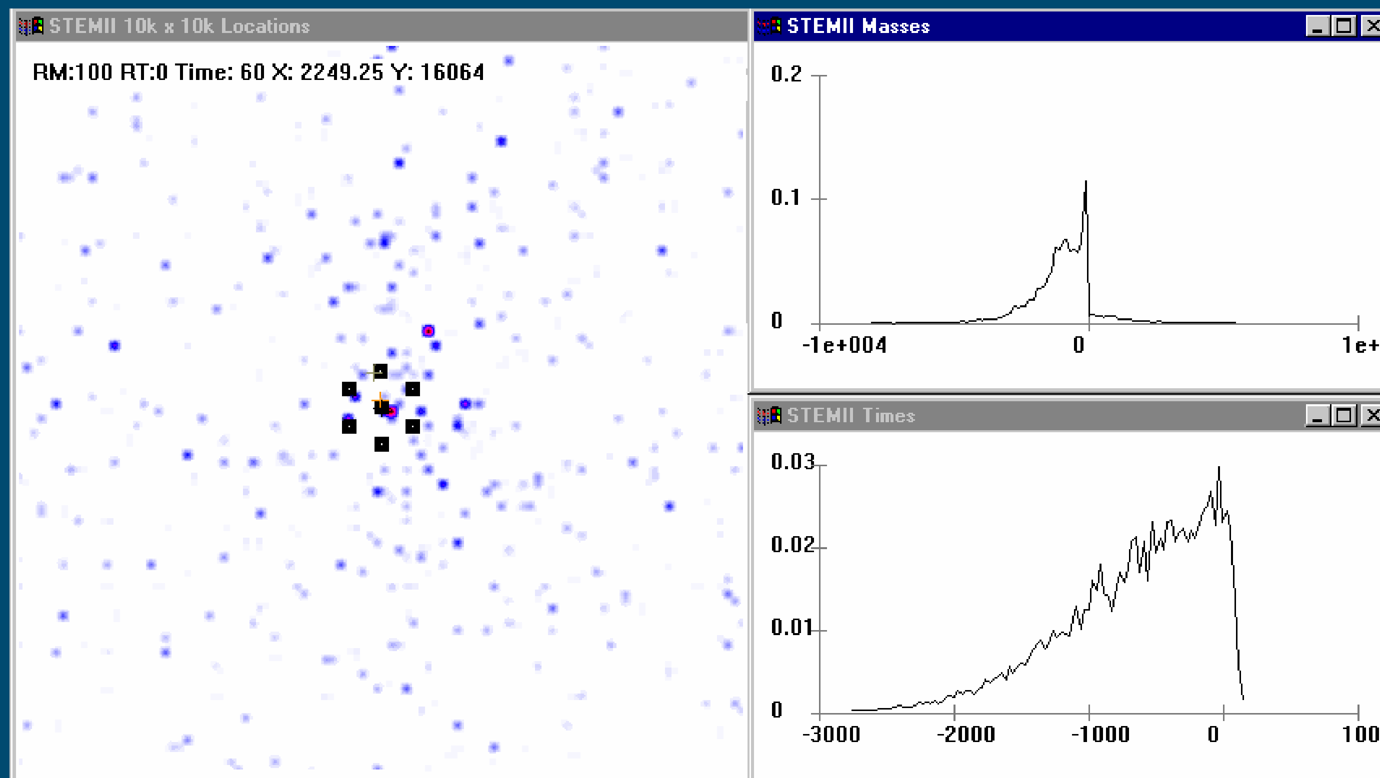


Source Term Estimation video

Chemical scenario

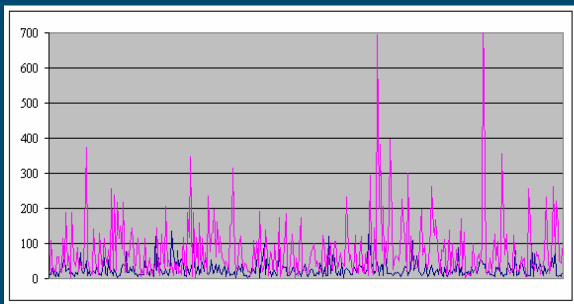
(faster than real time 1s = 1m)

- Actual releases:
  - Mass 100kg.
  - Time 0s.
  - 7 x bar detectors



Biological sensor fusion

- Biological background



Real background

Exponentially weighted moving av. of Poisson distributed background

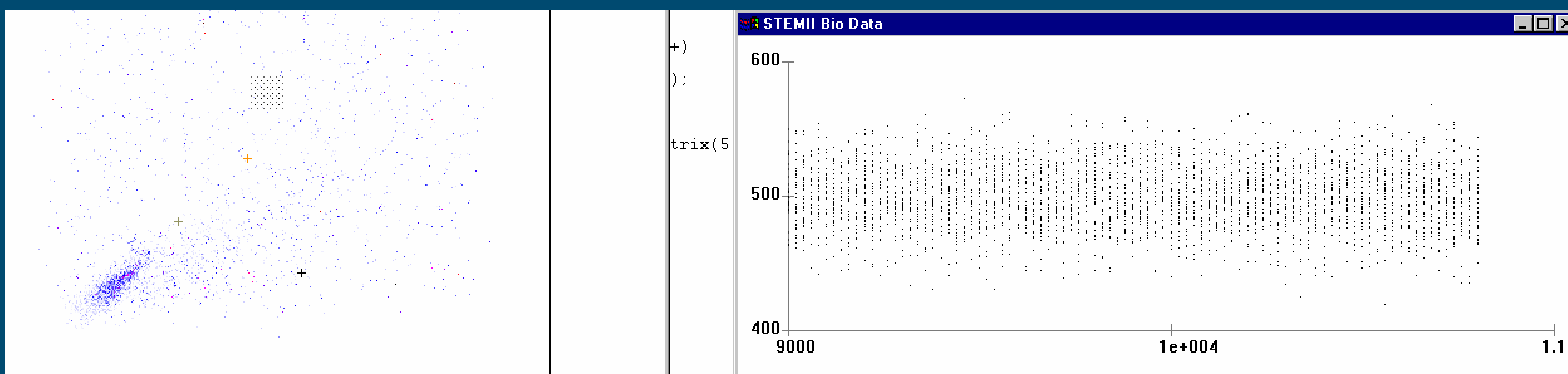
$$\mu_t = \alpha\mu_{t-1} + (1-\alpha)s_{t-1} \; .$$

i.e. mean = variance

STEM's internal model of background

Source Term Estimation

bkgrd subtracted sensor reading



Video of EWMA background discrimination (inc. simplistic background model)

Biological sensor fusion

- Biological sensor model

Simple particle counter sensor

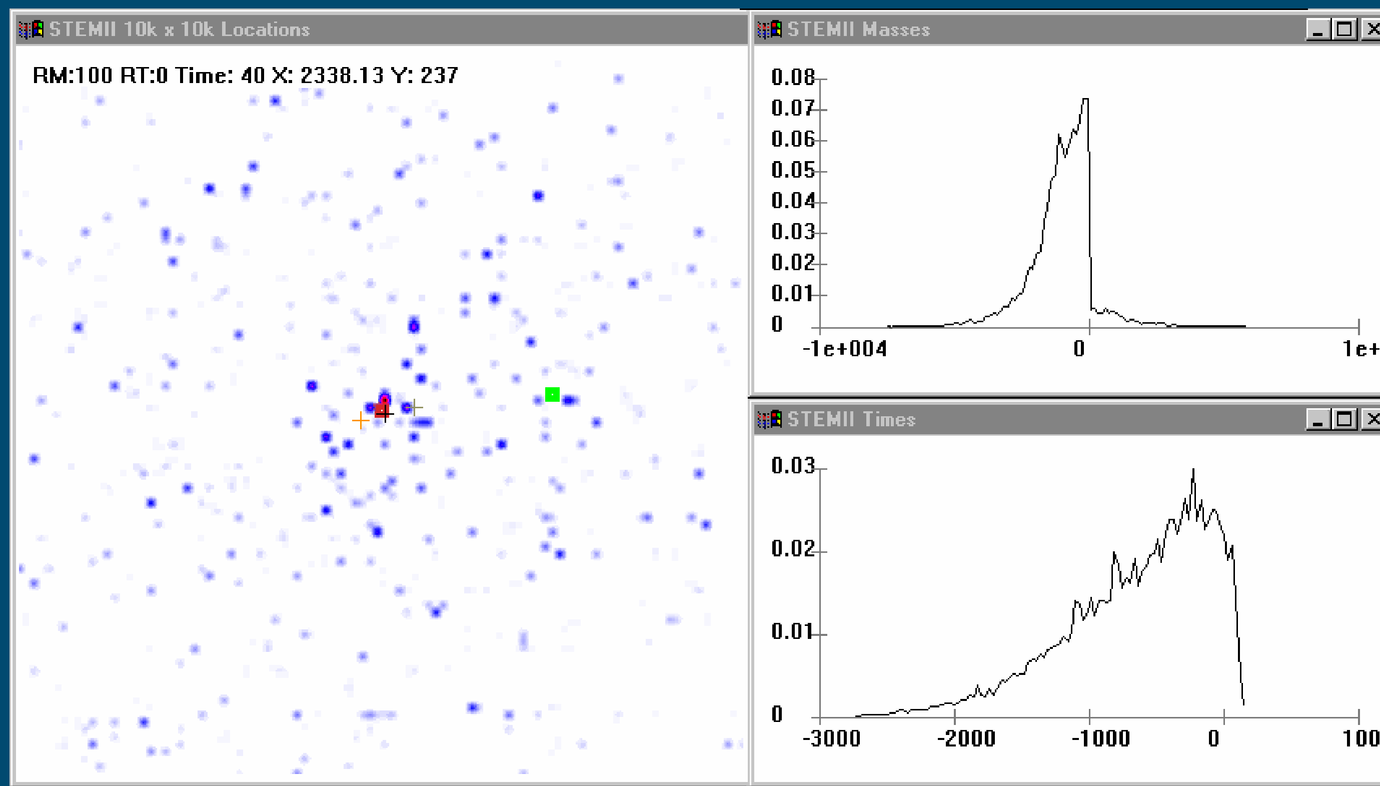
Immuno-Assay detector

Source Term Estimation video

Biological scenario

(faster than real time 1s = 1m)

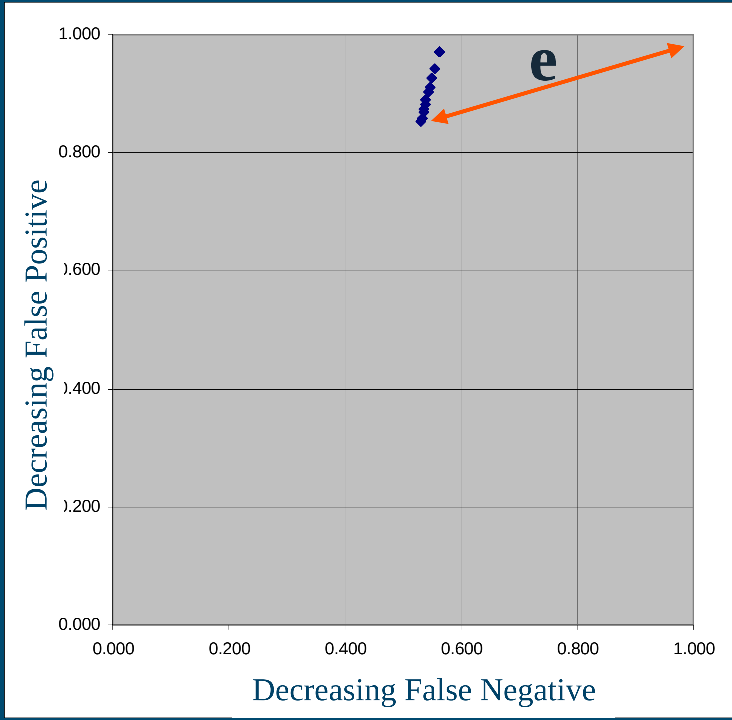
- Actual releases:
  - Mass 100kg.
  - Time 0s.
  - 1 x particle counter

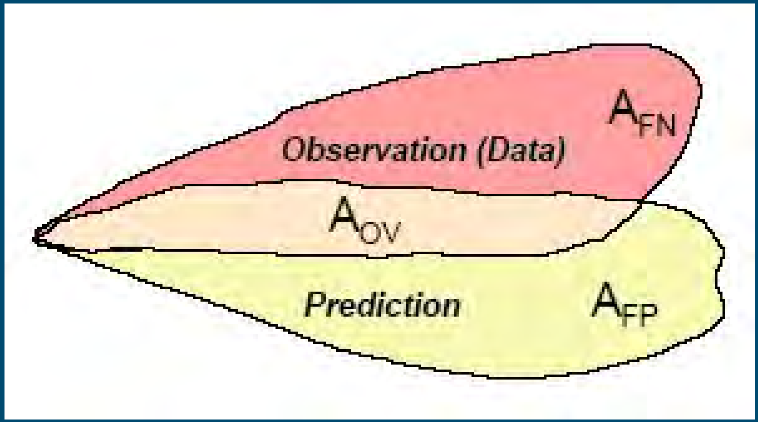


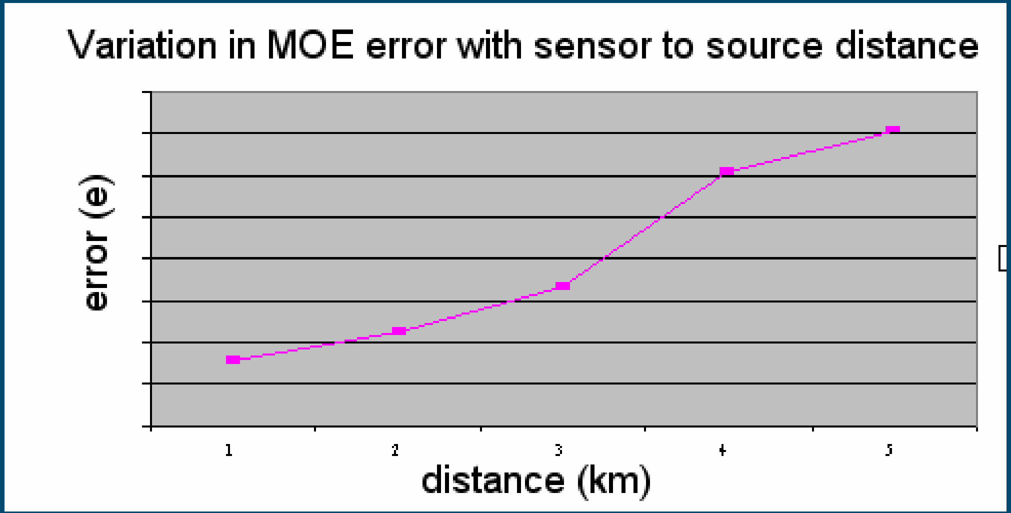
Evaluation of methodology

- Evaluation system built

- Measure of effectiveness – compares the areas of overlap, over and under-prediction between an the observed and predicted.







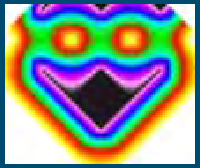
Peer Review

- Two papers presented at Fusion 2005 conference
- (Philadelphia, USA. July 25 - 29, 2005)

- **“Non-Linear Bayesian CBRN Source Term Estimation”.** Peter Robins and Paul Thomas
- **“A Probabilistic Chemical Sensor Model for Data Fusion”.** Peter Robins , Veronica Rapley and Paul Thomas

Future Research FY05 & FY06

- Extensive evaluation of STEM II will be carried out to determine performance in a synthetic environment
- More probabilistic models of sensor response will be built
- Extending the techniques developed for chemical releases to work for biological releases, in the presence of the natural background.
- Research will be carried out in order to speed up some of the more difficult mathematical calculations to make the system suitable for operational use in complex terrain and urban areas.
- Research will be carried out to allow modelling of multiple source terms and line strikes.



Questions?